EFFECT OF SOCIOECONOMIC DISADVANTAGE ON BIRTH OUTCOMES THROUGH SUBSTANCE USE, INDOOR AIR POLLUTION AND FOOD INSECURITY USING STRUCTURAL EQUATION MODELING.

M.Sc. THESIS

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UNIVERSITY OF GONDAR

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FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN BIOSTATISTICS

ADVISOR: SALIE AYALEW (PhD.)

APPROVAL SHEET-I

This is to certify that the thesis entitled with **"Effect of Socioeconomic Disadvantage on Birth Outcomes through Substance Use, Indoor Air Pollution And Food Insecurity Using Structural Equation Modeling."**, submitted in partial fulfillment of the requirements for the degree of Master of Science in Biostatistics in the graduate program of department of Statistics, University of Gondar, and it is a record of original research carried out by **Yeshambel workie ID. No. GUR/5356/06** under my supervision and no part of the thesis has been submitted for any other degree or diploma.

The assistance and the help received during the course of this investigation have been duly acknowledged. Therefore, I recommend that the thesis would be accepted as partial fulfillment of the requirement for Master of Science.

Name of Advisor	**Signature**	**Date**

APPROVAL SHEET-II

We, the undersigned, members of the board of examiners of the final open defense by Yeshambel workie have read and evaluated his thesis entitled with **"Effect of Socioeconomic Disadvantage on Birth Outcomes through Substance Use, Indoor Air Pollution And Food Insecurity Using Structural Equation Modeling."** and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in statistics with specialization of Biostatistics.

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Lists of Acronyms

ANOVA	Analysis Of Variance
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CSA	Central Statistical Agency
EDHS	Ethiopian Demographic and Health Survey
FAO	Food and Agriculture Organization
LBW	Low Birth Weight
LMP	Last Menstrual Period
MDG	Millennium Development Goal
ML	Maximum Likelihood
PCA	Principal Component Analysis
PTB	Preterm Birth
RMSEA	Root Mean Squared Error of Approximation
SED	Socioeconomic Disadvantage
SEM	Structural Equation Modeling
TLI	Tucker-Lewis Index
WHO	World Health Organization
WLS	Weighted Least Square
WLSMV	Weighted Least Square Mean-and Variance Adjusted
WRMR	Weighted Root Mean Squared Residual.

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Abstract

The pathway that links socioeconomic disadvantage to birth outcomes is not known. Data on the link between socioeconomic disadvantages to birth outcomes are important for planning maternal and child care services. Hence, this study aimed to determine the prevalence and examine the pathway between socioeconomic disadvantage and birth outcomes of a maternal exposed to indoor air pollution, food insecurity and substance use during pregnancy among deliveries at Gondar teaching referral and Bahir Dar Felege Hiwot referral hospitals, North West Ethiopia. Institution based cross-sectional study was conducted from May 1, 2015 to May 30, 2015 at Gondar and Bahir Dar referral hospitals. Primary data were collected using a structured questionnaire. Gestational age was determined based on the last menstrual period and birth weight was measured following the standard procedures. After wealth index was calculated using principal component analysis, structural equation modeling was applied to find the mediating factors of socioeconomic disadvantage to birth outcomes. The prevalence of low birth weight was 13.5% and the prevalence of preterm birth was 15.0%. Based on the fit indices, mean and variance adjusted weighted least square estimator is better than maximum likelihood estimator to estimate the model parameters of this study. Socioeconomic disadvantage was directly and negatively associated to gestational age but not directly associated to birth weight. Indoor air pollution, food insecurity and substance use were negatively associated to birth weight, and gestational age was positively associated to birth weight after adjusting sex of the infant. However, indoor air pollution, food insecurity and substance use were not significantly associated to gestational age. The pathway that links socioeconomic disadvantage to birth weight was indoor air pollution, food insecurity and substance use. Indoor air pollution, food insecurity and substance use did not mediate the pathway between socioeconomic disadvantages to gestational age. There is high prevalence of low birth weight and preterm birth in this area. Hence intervention and preventive strategies should focus on indoor air pollution, food insecurity and substance use behavior of mothers during pregnancy.

Key words: Birth weight; gestational age; structural equation modeling.

1 Introduction

1.1 Background of the study

Birth weight and gestational age are two of the determinants of the future health status of the infants. Birth weight expressed in terms of Low Birth Weight(LBW) and gestational age, in terms of Preterm Birth(PTB) constitute the highest rate of all the adverse birth outcomes in the world and are common in developing countries(1). Depending on the world health organization(WHO), preterm birth is defined as all births before 37 completed weeks of gestation or fewer than 259 days, since the first days of women's last menstrual period (2).

Even though no currently WHO estimates of global prevalence of preterm birth is available (2) the 2010 report indicates that over 135 million live births worldwide about 15 million babies were born too early, representing a preterm birth rate of 11.1%. Of these 15 million preterm births over 60% of preterm births occurred in South Asia and Sub-Saharan Africa.

Low birth weight is defined by world health organization as weight at birth less than 2500g (5.5 pounds). According to WHO data the current estimate of LBW is between 15% to 20% of all births in the world which representing more than 20 million births a year (3). The prevalence of LBW across regions and within countries is different. The majority of low birth weight occurs in low and middle income countries. According to the WHO regional estimates of low birth weight the highest 28% in South Asia, 13% in Sub-Saharan Africa and 9% in Latin America (3).

According to the demographic health survey of Ethiopia reports (4) shows that the prevalence of low birth weight infants are 21% which is higher than the global estimates. For some institution based survey a study done in Gondar teaching referral hospital the prevalence is 11.2% (5). There was methodological difference in measuring birth weight in these studies. The Ethiopian demographic and health survey report was mainly based on subjective maternal assessment of birth weight while in the institution based survey the birth weight was measured by standard procedures and instruments.

Globally, Low birth weight continuous to be significant public health concern and is associated with a range of both short-term and long term consequences. Baby's weighing less than 2500 grams have higher mortality and morbidity rate than babies born at normal weight. LBW is also linked with chronic diseases risk across the life course such as obesity, type2 diabetes and hypertension(3).

From 15 million preterm births more than 1 million died as a result of their prematurity(3). Preterm birth are now the second leading cause of death in children less than five years and the single most important cause of death in the critical first month of infants. The survival chances of 15 million babies born prematurely every year vary depending on the place where they are born. The risk of infant death due to preterm birth in Africa is 12 times higher than the European baby (3).

Preterm babies that do survive had a lot of problems in their life course such as neurodevelopmental impairment, mental retardation, cerebral palsy, sensory deficits, behavioral problems and respiratory and gastro intestinal complications(6).

Preterm birth and low birth weight are not mutually exclusive. Almost two-thirds of preterm infants are also low birth weight because of preterm birth is one of its primary cause of low birth weight. Both of these adverse birth outcomes are associated with an increased risk of infant mortality (7).

In Ethiopia, poor birth outcomes are still the major public health problems. The achievement of millennium development goal (MDG) 4 is strongly influenced by progress in reducing neonatal death. Since poor birth weight and poor gestational age are the leading cause of neonatal mortality. Information on poor birth outcomes is very important to take evidence-based interventions that halt neonatal death.

In general, data on maternal exposure to risk factors and their magnitude on poor birth outcomes are important for planning maternal and infant health care service in developing countries. Hence this study aimed to determine the direct and indirect risk factors of poor birth outcomes at Gondar teaching referral hospital and Bahir Dar Felege Hiwot referral hospital.

1.2 Statement of the problem

A poor birth outcome is one of the world's major public health problems and its burden is high in developing countries. Of 135 million live births per year 15 million babies born with prematurely and 20 million (one in five babies) born with low birth weights (3).

The prevalence of adverse birth outcomes in Ethiopia are different for a study done by different researchers. According to the demographic health survey of Ethiopia, the prevalence of low birth weight of infants are 21% which is higher than the global estimates(4). In an institution based study done in Gondar referral hospital the prevalence was 11.2% (5), almost a double difference. It is not clear whether this difference is due to the methodological variations or not. Of course, the EDHS report was mainly based on subjective maternal assessment of birth weight as big, normal, small and very small used as a proxy variable to measure birth weight which might lead to a systematic error. While for the institution based survey the birth weight is measured by standard procedures and instruments within an hour of birth. So population based studies using subjective methods may not be appropriate to identify those risk factors associated with adverse birth outcomes for two reasons; firstly, they are used a proxy variables to measure birth weight. Secondly, there is a campaign in Ethiopia "andm enat bewolid miknyat memot yelebatm" by ministry of health Ethiopia and the availability of ambulance for each Woreda because of this most mother delivered at hospitals and health centers. Hence due to this two reasons institution based study is appropriate to identify the associated risk factor of poor birth outcomes.

Most poor birth outcome studies frequently used a single factor approach (5, 8). So they are limited in their ability to determine how factors act together. Instead the variables that could influence birth outcomes are construct variables that could be measured by indicator variables such as socioeconomic position measured by education, marital status, type of residence and wealth index. The other constructs which were not addressed by other studies in Ethiopia are indoor air pollution, food insecurity and substance use. This study identifies the association between these construct variable and birth outcomes using structural equation modeling. The advantage of these model to that of the traditional statistical analysis models were that the impact of the construct variables on the outcomes (gestational age and birth weight) and their relationship between the construct variables can be tested within a single analysis.

As far as to my knowledge there is no study done in Ethiopia regarding the relationship between exposure variables such as socioeconomic disadvantage, food insecurity, indoor air pollution and substance use and birth outcomes as construct. Thus, the aim of the present study was to use SEM technique to examine the pathway between socioeconomic disadvantage and birth outcomes of a maternal exposed to indoor air pollution, substance use and food insecurity constructs variables during pregnancy.

1.3 Objective of the study

1.3.1 General objective

The general objective of this study was to determine the prevalence of preterm birth and low birth weight and to examine the direct and the indirect determinants of birth outcomes or to find the pathway that links socioeconomic disadvantage to birth outcomes.

1.3.2 Specific objectives

The specific objectives of this study were:

- To find the prevalence of low birth weight.
- To find the prevalence of preterm birth.
- To find the direct and indirect determinant of birth weight.
- To find the direct and indirect determinants of gestational age.

1.4 Significance of the study

This study has the purpose to model the mediating role of indoor air pollution, food insecurity and substance use through socioeconomic disadvantage and birth outcomes. The findings from this study were expected to give information for public health practitioners and stack holders who are working in the area of maternal and under five children health. It also provides evidence-based intervention for policy makers and program managers regarding to reduce the poor birth outcomes. It also serves as a basis for further study in this area.

1.5 Limitation of the study

This study was cross-sectional, conducted by interviewing the mother's regarding to gestational age and exposure to risk factors during their pregnancy hence it might be affected by recall bias. Because this study is done at referral hospital it does not show the real picture of poor birth outcomes of the area where the study is conducted. The other limitation was that structural equation modeling has no standard ways of determining sample size(9).

1.6 Organization of the paper

This paper was organized into five sections. The first section deals with introduction part mainly focus on statement of the problem and objective of the study. The second section focuses on literature reviewed. The third section deals with methodology including the study design, the study area, sampling procedure, sample size determination, data source and collection instruments, the model and data analysis. The fourth section illustrates the expected result and discussion of results. The final section states about conclusion and recommendation.

2 Literature Review

2.1 The prevalence of poor birth outcomes

Poor birth outcomes such as low birth weight and preterm birth are major public health problems in developing countries and are major determinants of perinatal survival, infant morbidity and mortality as well as risk of developmental disabilities and illness throughout their life course(3). These adverse birth outcomes are also a leading indicator of maternal health status during pregnancy and the future of the infant health (10).

According to WHO estimates indicated that over 135 million live births worldwide per year, about 15 million babies were born too early, representing a preterm birth rate of 11.1%(2). From these 15 million preterm births, over 60% of preterm births occurred in South Asia and Sub-Saharan Africa. This shows that the problem of PTB in these two regions is deep rooted and Ethiopia is one of the Sub-Saharan African countries were the prevalence of PTB expected to be high even though there is no country level prevalence of preterm birth. However, a study done in North West Ethiopia at Gondar teaching referral hospital showed that the prevalence of PTB was 14.3%(5). A study done in Iran showed that the prevalence of PTB was 15.5% (11). Another study done in Ghana, showed that the proportion of PTB was 17% (12).

Annually, it is estimated that more than 20 million low birth weight babies were born globally, making up 15% to 20% of all live births. Most of low birth weight babies born in developing countries. The estimated low birth weight in Asia is 28% and Sub-Saharan Africa is 13% (3). A study done in Ghana, the proportion of LBW was 41%(12). Another study done in Guatemala showed that the prevalence of LBW among hospital births was 18.8%(13). In Ethiopia, approximately 21% of infants were estimated to weigh less than 2500g at birth (4). A study done in north western Ethiopia at Gondar teaching referral hospital, the prevalence is 11.2% (5). Another study done in south western part of Ethiopia revealed that 22.5% prevalence of low birth weight among health institution deliveries (14). This high variation with in the country may be due to methodological difference as well as most deliveries occur in homes.

A study done at Gondar University using multilevel logistic regression model showed that the determinants factor of low birth weight are mother's education, socioeconomic status, parity, sex of a child, type of birth, mother's age at first birth, mother's body mass index, anemia and number of antenatal care visit(8). Also another study done at Gondar teaching referral hospital, using logistic regression model showed, adverse birth outcomes are associated with history of perinatal death, delivering preterm or small baby, ante partum hemorrhage, lack of antenatal care follow up and hypertension(5). However, there is no study done on a maternal exposed to indoor air pollution, food insecurity and substance use behavior of the mother during pregnancy as well as the pathway that links between socioeconomic disadvantages to birth outcomes. Therefore, this study fills this gap.

2.2 Determinants of poor birth outcomes

2.2.1 Effects of socio-economic disadvantage

Socioeconomic disadvantage is a complex construct that has been used to define social inequality and this construct was measured by maternal education, wealth index, type of residence and marital status. Socioeconomic disadvantage does not directly affect birth weight. But they affect through the exposure or the mediating variables such as food insecurity, indoor air pollution, substance use/abuse, stress, anxiety, depression, physical demanding work etc. (15). Of these mediating variables only food insecurity, indoor air pollution and substance use were included in this study. Many studies have been found that maternal socioeconomic factors measured by maternal education, maternal occupation, marital status, type of residence and household income are associated with poor birth outcomes (5, 8, 15-18). Among the widely studied socioeconomic variables that determine poor birth outcomes is education of women which is one of the most important socioeconomic factors having a direct and an indirect influence on adverse birth outcomes through its impact on maternal food security, the choice of type of fuel used for cooking and maternal substance use behavior (19).

A socioeconomic disadvantage of a mother is consistently associated with increased risk of low birth weight and preterm birth (20-22). For example a study was conducted in Bangladesh with the objective of analyzing socioeconomic determinants of low birth weight using logistic regression model. About 23.2% of infants were low birth weight. It was reported that education and yearly income are associated with low birth weight. In this study educational level and yearly income plays a significant role in the incidence of low birth weight (23).

A study done by Dolatiana, a path analysis showed that among the socioeconomic factors income, and mother's education had the greatest overall effect on gestational age at birth (11). Another study by Blumenshine showed in his systematic review study that, there is a strong effect of maternal socioeconomic disadvantage and preterm labor (21).

A study done Ghana showed that poor pregnancy nutrients and indoor air pollution substantially mediated the observed effects socioeconomic disadvantage on birth weight and gestational age(12).

The pathway through socioeconomic disadvantage influences birth outcomes.

A number of studies have highlighted the indicators of maternal socioeconomic disadvantage(SED) (e.g., family wealth, low education, type of residence and not living with a partner) that are associated with birth weight and gestational age at birth (5, 8, 14, 23-25). However, less is known about the pathways that link the construct of maternal socioeconomic disadvantage to birth outcomes(15). Several potential pathways linking maternal socioeconomic disadvantage and infant birth outcomes have been suggested (12, 15, 26) and synthesized below.

Food insecurity

The first pathway that links the effect of SED to birth outcomes is through food insecurity. A maternal characteristics such as having a low level of income, low education ,living in a single headed household, and having many children in the household have been found to have an increased risk of experiencing food insecurity. Furthermore, the associations between this factor and the risk for food insecurity are strong for women. These maternal risk factor for food insecurity happened during pregnancy leads to a modifiable risk factor for poor birth outcomes(27).

A study done in Tanzania showed that food insecurity was associated with assets, flooring materials and land ownerships. In addition, it was also showed that the construct of food insecurity and socioeconomic position are distinct and they are not overlapping (28).

A study conducted in rural area of Malaysia by sheriff and khar's found that food insecure women had less education, lower household income, and greater number of children than did women from food secure households and also maternal were more likely to be a housewives as opposed to having other activities(29).

Substance use

The second pathway that links the effect of SED to birth outcomes via substance use such as alcohol consumption, chat chewing and illicit drug use. Household socioeconomic disadvantage is associated with substance use. Previous studies showed that a pregnant women in the lower socioeconomic status more frequently used substance for a copping mechanism to stress and less access to financial resources. The lower the mother in the socioeconomic hierarchy, the more likely she is to experience to drink alcohol and using illicit during pregnancy (16, 30).

Indoor air pollution

The third pathway that links the effect of SED to birth outcomes is through indoor air pollution. A number of study showed that there is an inverse relationship between the indictors of socioeconomic factors (such as education, and income) and indoor air pollution (12, 16). Indoor air pollution decreases as mother from high educational level and the highest income quintiles.

2.2.2 Maternal Food Insecurity and adverse birth outcomes

Food insecurity is defined as "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways"(31). Food insecurity is a prevalent problem in Ethiopia where 29. 6% of the population living below the poverty line (32). Pregnant women are also part of this population and the problem of food insecurity is also high among the pregnant mother. However, inadequate data exist on the association between food insecurity and poor birth outcomes in Ethiopia. This study will identify the association between food insecurity during pregnancy and poor birth outcomes.

A study conducted by Borders et al. using multivariable logistic regression models by controlling maternal age indicated that the odds of low birth weight among food insecure mother is 2.6 times higher than for those food secure mothers. This shows that food insecurity during pregnancy is positively associated with low birth weight (33).

A study done in Ghana in their causal pathway analysis showed that poor nutrition was mediated 2-51% of the observed effect of socioeconomic disadvantage on birth weight(12).

2.2.3 Indoor air pollution

Generally, 41% of the world's household, mainly in developing countries such as Asia and Sub-Saharan Africa rely on solid fuel (such as wood, charcoal, dung and plant residue) as their primary cooking fuel. Indoor air pollution from solid fuel was accounted to 4.5 million deaths globally in 2012, almost all in developing countries(34).

Evidence exists that, maternal exposed to indoor air pollution during pregnancy had adverse effects on different birth outcomes (35). A study done from Ghana identified indoor air pollution was pathway that links socioeconomic disadvantage and birth outcomes and explained most of the variation and adversely affect birth outcomes(12). A study from Guatemala identified an association between birth weight and type of fuel used. From this study the result showed that babies of mothers using open wood fires were on average 63 g lighter compared with babies born to mothers using cleaner fuels (13). A similar effect has also been reported in Zimbabwe (36).

2.2.4 Substance use

Alcohol consumption during pregnancy has adverse effect on fetal development and also they increase the risk of poor birth outcomes. Some study showed that women who take alcohol two times a day have an increased risk of poor gestational age (37). Another study revealed that alcohol consumption during pregnancy was significantly associated with birth weight ($p < 0.02$). Moreover, there was also a risk in low birth weight associated with increasing amount of alcohol intake during pregnancy. There was a significant association between the mean birth weight of the singletons across different categories of alcohol intake ($p < 0.0001$). The difference between the mean birth weights of the singletons among moderate drinkers compared with nondrinkers was also statistically significant ($p < 0.005$). These relationships remained after simultaneously adjusting effects of the confounding variables gestational age, parity, smoking, weight gain, maternal age and education in multiple regression analyses. Additionally, it is shown here that for moderate alcohol use during pregnancy, there is an adverse effect on the birth weight(38).

A path analysis done by James et al. is that, the relationships between SED and both gestational age and birth weight were completely mediated by substance use behavior of the mother during pregnancy. The indirect effects of SED on gestational age and birth weight were negative and significant ($\beta = -.02$, $P < .001$; $\beta = -.02$, $P < .001$, respectively)(30).

A study done using multivariable logistic model on birth outcomes, especially on continuous birth weight and low birth weight, the result showed that drug use during pregnancy were related to birth weight decrement and an increased odds ratio of low birth weight(39).

In summary, there is no study done on the mediating effect of socioeconomic disadvantage to birth outcomes using structural equation modeling where the mediating effects are indoor air pollution, food insecurity and substance use during pregnancy. The advantage of using SEM special from other statistical techniques are it has an ability take into account measurement errors; it can also model multiple dependent variables simultaneously. The other issue here is that most of the studies used to measure socioeconomic disadvantage are maternal education, family income, marital status, residence and types of occupation. This does not work for developing countries like Ethiopia where most of the people live in rural areas and there is no habit to tell their monthly income to the second party. Hence it is better to use wealth index instead of income to measure socioeconomic disadvantage of a mother. Hence, this study fills this gap.

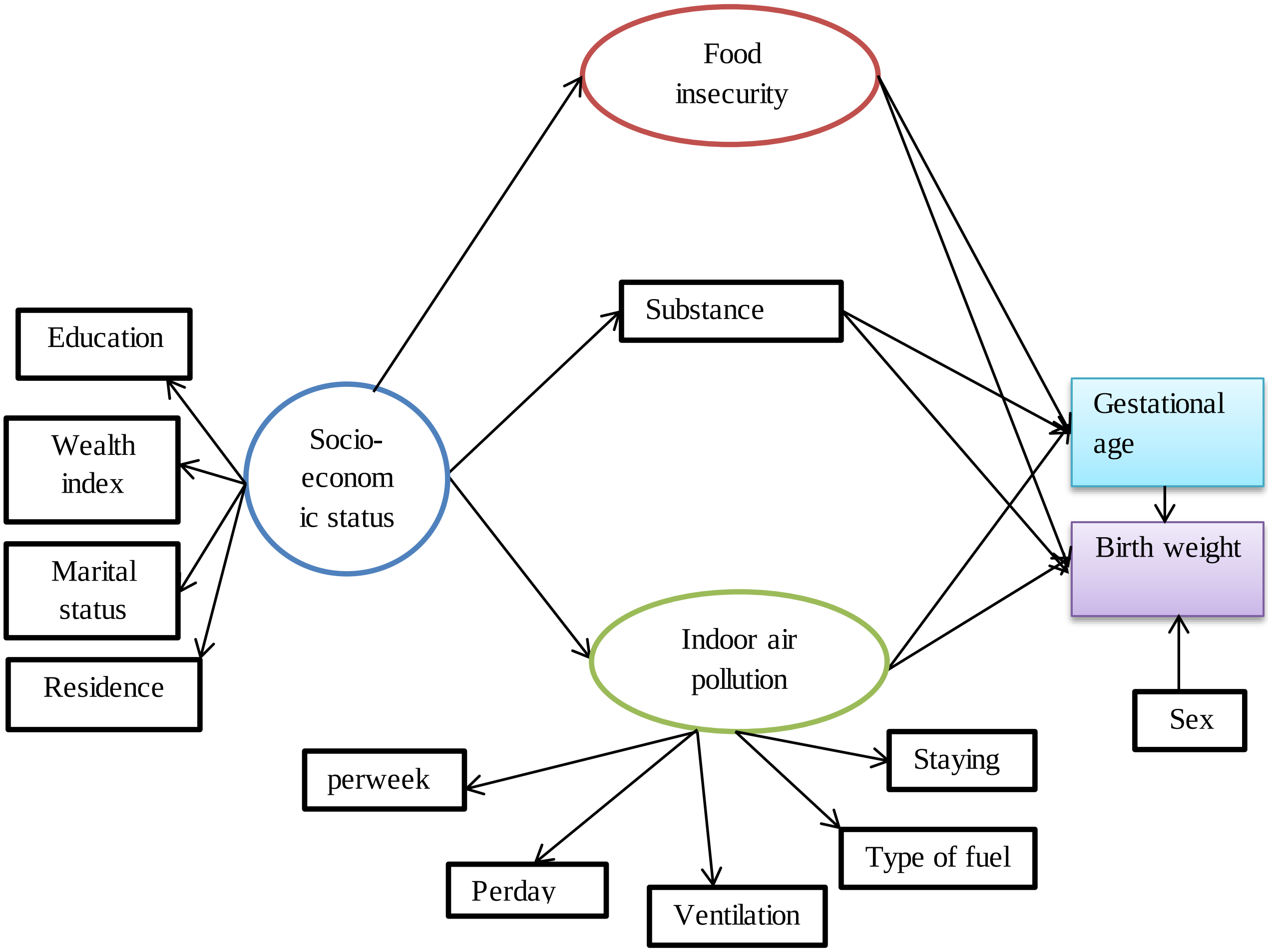


Figure 2.1 Conceptual framework of the pathway through socioeconomic disadvantage to birth outcomes

3 Materials and Methods

3.1 Study Designs

Institution based cross-sectional quantitative study has been conducted from May 1, 2015 to May 30, 2015 among new born neonates in Gondar teaching referral hospital and Bahir Dar Felege Hiwot referral hospital, North West Ethiopia.

3.2 Source population

The source population was all women of reproductive age group 15 –49 seeking delivery services and residing in North West Ethiopia.

3.3 Study population

The study population comprises of those women who gave birth in Gondar teaching and Bahir Dar Felege Hiwot referral hospitals during the study period and whose age were 15-49 years and residing in North West Ethiopia.

3.4 Sample Size determination

The sample size depends on the purpose of the study, available resources, and the required level of precision and the scale of the outcome variables. According to William Cochran there are four ways of estimating population variance for sample size determinations.

1. By taking the sample in the two steps, the first being a simple random sample of size n_o from which estimates s^2or p of S^2 or P and the required n will be obtained.
2. Use pilot study results.
3. Use data from previous studies of the same or similar populations.
4. Estimate or guess the structure of the population assisted by some logical mathematical results.

By taking into consideration the above determinant factors and also our outcome variable is continuous and assuming that they are normally distributed we used this formula (40)

$$n_o = \frac{\left(z_{\frac{\alpha}{2}}\right)^2 s^2}{e^2}$$

Where

- ✓ $\mathbf{n_0}$= number of the study subjects.
- ✓ **Z**= is standardized normal distribution curve /value for the 95% confidence interval (1.96).
- ✓ S^2=the variance of birth weight of an infant. As to our review of literature, we couldn't come across with studies about the variability of birth weight. As a result, we conducted a pilot survey of size 40, and we found it to be 0.273686 kg(40).
- ✓ **e**= the level of precision (0.05 taken).

$$n_o = \frac{(1.96)^2 (0.273686)}{(0.05)^2} \approx 421$$

Since our population is infinite (greater than 10,000), we decided not to take finite population correction formula.

$$\frac{n_o}{N} * 100 = \frac{421}{10500} * 100 = 4\% \leq 5\%$$

$$n = n_0 = 421$$

The total sample size for this study was 421 mothers.

3.5 Inclusion and Exclusion criteria

3.5.1 Inclusion

All mothers who give live birth and whose age 15-49 years were included in the study.

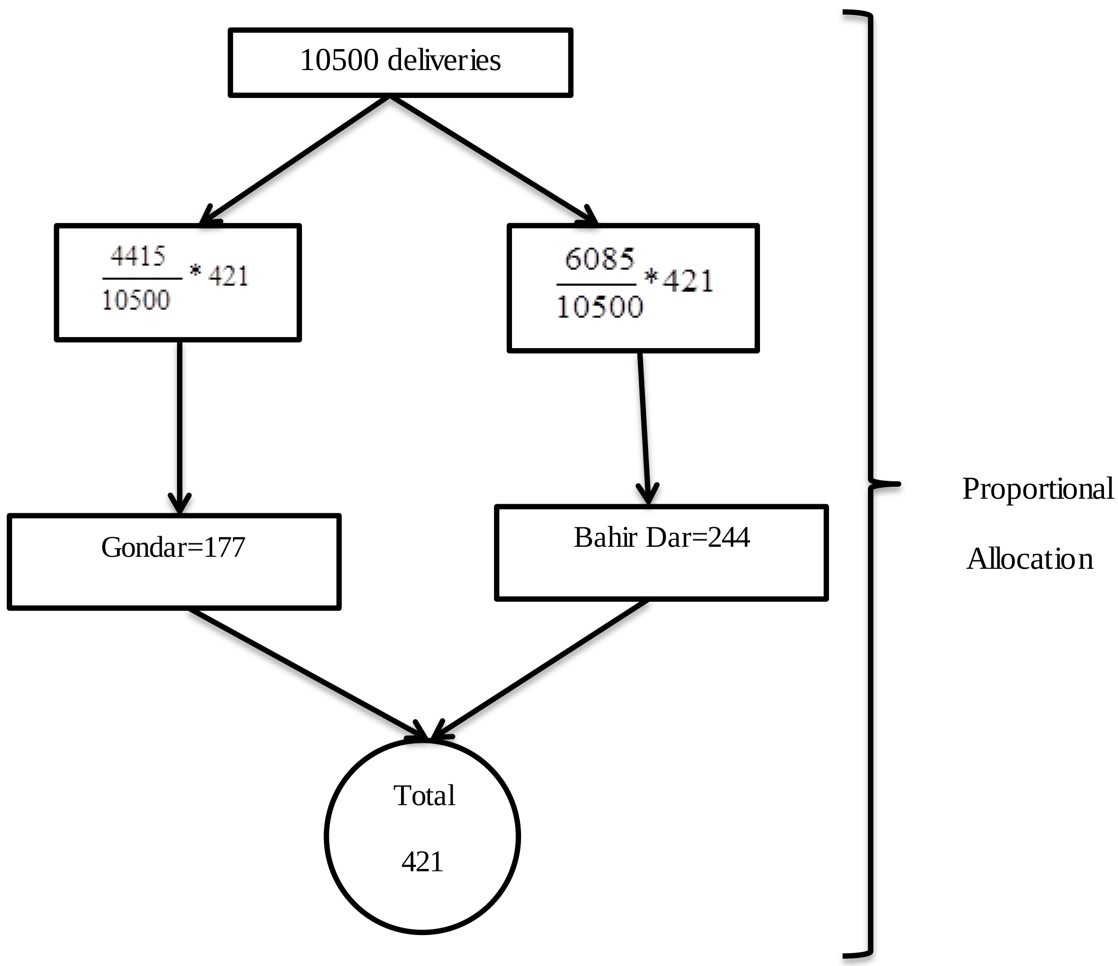
3.5.2 Exclusion

All mothers who gave still birth during the study period were excluded from the study.

3.6 Sampling technique/procedure

The sampling technique for institution based survey was very difficult because of the unavailability of sampling frame. This study includes two referral hospitals found in North West Ethiopia. The only information available in this two hospitals related to delivery service were the annual planned delivery service and on average the number of deliveries per day. The annual planned delivery services given for the 2014/15 were 6085 and 4415 deliveries for Bahir Dar and Gondar referral hospitals respectively. The average deliveries per day for each institution were

10-15 for Gondar hospital and 15-20 for Bahir Dar hospital. Based on these information's we allocated our sample into Gondar and Bahir Dar hospitals using proportional allocation to the size of the planned annual delivery services.



The monthly deliveries for each institute are 368 and 507 deliveries depending on the annual plane of Gondar and Bahir Dar referral hospitals respectively. The study period was May 1, 2015 to May 30, 2015. The monthly planned deliveries were taken as a frame. Simple random sampling technique can't apply because there is no list of deliveries. Hence, systematic random sampling was applied to select mothers. To apply systematic random sampling techniques, first divide the 368 deliveries to 177 for Gondar referral hospital and divide 507 deliveries to 244 for Bahir Dar referral hospital to find the intervals. In both cases our interval was two. From one and two, using simple random sampling technique one was selected. Therefore, systematically every other mother was taken until our sample size was fulfilled.

3.7 Data collection

The data collectors were midwives who had experienced and working in respective health institutions in the department of obstetrics and who were providing obstetric service for their clients. The data collectors were trained by the principal investigator on the objectives of the study and how to interview, fill the questionnaire and handle questions asked to clients during interviewing. The interview was conducted after the mother gave birth and the neonatal weight was measured within two hours after delivery. During the data collection process each questionnaire was checked daily by the supervisor and principal investigator for its completeness and accuracy.

3.8 Data sources and the questionnaire

In this study we use primary source with structured questionnaire to collect quantitative primary data on socio-demographic information, economic, substance use; indoor air pollution and food insecurity during pregnancy each mother was asked within two hours after delivery. Gestational age and birth weight of a new born baby was taken from maternity delivery catalog. The questionnaire was prepared in English language then translated into Amharic language.

3.9 Variables

The structural equation modeling includes both directly observed variables and unobserved variables known as latent variables or factors or constructs.

3.9.1 Socioeconomic disadvantage at the time of delivery

Socioeconomic disadvantage at birth was treated as a latent variable measured using the following indicators: wealth index, maternal education and marital status. A household wealth index was created using principal component analysis (PCA) based on ownership of the following household assets. The assets included in the PCA are Electricity, Television, Mobile, Chair, Table, Bed, Lamp, size of land holding, types of farm animals by type, book of account, Floor material, wall material, Roof material, source of drinking Water, Toilet type, Type of fuel used for cooking. PCA is a multivariable statistical technique used to reduce a set of correlated variables into fewer dimensions. The first principal component was used to calculate the wealth index for a given asset. A three separate wealth indexes were calculated such as combined index, a rural-specific index and an urban-specific index. A combined index was constructed based on the assets common to both rural and urban areas. So we have two scores for each respondent and adjustment of values can be found by regressing each respondent's area- specific index scores onto its combined index scores. Finally a combined wealth index was constructed by using the estimated combined wealth scores for each respondent. This wealth index substitutes the income measure of socioeconomic disadvantage and it was better represents the economic status of the mother. Why we used this indicator as measure of socioeconomic disadvantage was that our society does not have a culture to told their incomes to the second party and as well as these research includes both rural and urban respondents which is difficult to know the monthly income of those respondent who live in the rural area. Because of these two reasons we want to calculate the asset measure of socioeconomic disadvantage. As far as to my knowledge this was the first study which included wealth index as an indicator for socioeconomic disadvantage so that some of the findings of this study might not consistent with previous findings.

Wealth index were categorized into five quintiles; 1=quintile one: 2= quintile two; 3= quintile three; 4= quintile four; 5= quintile five. Maternal education were categorized as 1=illiterate; 2=primary; 3=secondary; 4= above secondary. Marital status was also categorized into 1=unmarried; 2=married.

3.9.2 Food insecurity and substance use status at the time of pregnancy

Food insecurity at time of pregnancy was treated as a latent variable measured by 8 yes/no Items 0=No and 1= Yes adopted from FAO for Ethiopia (41) and their reliability was tested by Cronbach's alpha (α=0.823) which was above the cut-off point. Substance use was measured directly using the score of alcohol use and illicit drug use where the codes are 0= none; 1= alcohol use only; 2=drug use only; 3=both alcohol and drug use.

3.9.3 Indoor air pollution

Indoor air pollution was another latent variable measured by the observed variable. All mothers were using biomass fuel for cooking food during their pregnancy. The use of electricity for cooking purpose was not considered as risk factor to poor birth outcomes. As a result only the use of biomass fuels was considered to determine the status of indoor air pollution.

1. The frequency of cooking sessions per day during the current pregnancy.
2. The frequency of days for cooking food per week during this pregnancy.
3. Whether the mother stays in cooking room until the end of cooking session.
4. The type of number of biomass fuel used for cooking food.

3.9.4 Outcome variables

The outcome variables for these studies were birth weight and gestational age. Gestational age was estimated by the number of days between the first days of the last menstrual period(LMP) and date of birth expressed in a completed weeks after LMP as recorded in the maternity delivery catalog. Birth weight was measured using digital scale. This two outcome variables, birth weight and gestational age were taken as a continuous variable. Taking both birth weight and gestational age as a continuous variable had a number of advantages. First, it may allow for the detection of small effects that might not be apparent using dichotomized as low birth weight and preterm birth (42). Second, treating gestational age and birth weight as continuous variables increases statistical power to estimate covariate effects with precision, which in turn facilitates unseen true relationships when they exist (43).

3.9.5 Control variable

The control variable for this study was the sex of the infant. This variable was the known effect on birth weight from different studies(5). This control variable is included in the SEM to control confounding effects.

3.10 Data quality Issues

To keep the quality of the data, a two day intensive training was given for the data collector and the supervisors. Standard questionnaire was adapted from related studies and the English version were translated in to Amharic and then back to English to maintain its consistence for actual data collection purpose. Then, the questionnaires were tested for their accuracy and consistency prior to the collection of data outside the selected month on the same institution. Four diploma holder midwives were assigned for data collection for the two health institution and two supervisors were assigned for both hospitals. Data collectors were selected appropriately and were trained.

The data collection process was regularly checked by the supervisor and principal investigator for its accuracy and completeness.

3.11 Data entry and analysis strategies

The collected data had been code, enter, clean and the appropriate descriptive statistical analysis and cross tabs were done using Epinfo version 3.5.3 for entering data. Furthermore, MPLUS, SPSS, SAS and R statistical soft wares were used for data analysis.

Comparison was made between maximum likelihood (ML) and mean and variance adjusted weighted least square (WLSMV) estimators to select the best estimator based on their fit indices common to both estimators. An estimator with the best fit indices was applied to this study.

This study was an attempt to identify the pathway that links socioeconomic disadvantage and birth outcomes. We first applied descriptive analysis and bivariate analysis for assessing the distribution of birth outcomes, to know the socioeconomic characteristics of the respondents as well as the prevalence of low birth weight and preterm birth. In addition to this it was also used to assess the relationship between observed variables and birth outcomes. Second, we applied structural equation modeling to estimate direct and indirect effects of birth outcomes. . Modeling was done in two stages. First, we evaluated the measurement model by conducting a confirmatory factor analysis (CFA) of maternal socioeconomic disadvantage, food insecurity and indoor air pollution. Second, we analyzed the hypothesized structural model between latent variables and birth outcomes.

In this study there were seven specific indirect effects that links socioeconomic disadvantage to birth weight and three specific indirect effects that links socioeconomic disadvantage to gestational age. There are two direct effects of socioeconomic disadvantage to both birth weight and gestational age. The ten indirect pathways and two direct effects were explored simultaneously in structural equation modeling to test for the effects of possible direct and indirect effects between socioeconomic disadvantage and birth outcomes. All of them adjusted for confounder variable identified from previous study and by using bivariate analysis. The paths are;

The effect of socioeconomic disadvantage to birth weight was mediated by path-1 by indoor air pollution; path-2 by food insecurity; path-3 by substance use; path-4 by gestational age; path-5 by indoor air pollution and gestational age; path-6 by food insecurity and gestational age; path-7 by substance use and gestational age. The effect of socioeconomic disadvantage to gestational age was mediated by path-8 through indoor air pollution; path-9 by food insecurity; and the last path-10 by substance use.

3.12 Basics of structural equation modeling

Compared with traditional statistical methods such as multiple regression, path analysis, and multilevel models, the advantages of including SEM, but are not limited to, enable us to take into account measurement errors, model multiple dependent variables simultaneously, test overall model fit, estimate direct, indirect and total effects. However, SEM is still an underutilized technique in health studies in Ethiopia (44).

The majority of studies of the relationship between birth outcomes and socioeconomics disadvantage, indoor air pollution, substance use and food insecurity use multiple logistic regression models and do not explore potential pathways between the factors and birth outcomes(5, 8, 14, 18, 23). A few studies have attempted to examine mediation or indirect effects, yet often they do not analyze all paths in the model (12). Some scholars have suggested that other techniques, such as SEM, may be more appropriate for these types of analyses (45, 46). For example, they have noted that traditional approaches to mediation analysis in epidemiology do not take potential measurement error into account, which can lead to residual confounding or incorrect conclusions about direct and indirect effects. As some reproductive epidemiologists also have noted, the ability for SEM to model all regression equations simultaneously that is, to test all possible relationships between the variables in the model, including mediating effects and possible latent variable is one major advantage of SEM over separate logistic regression models (46) and all other analytic techniques (9).

3.12.1 Model specification

The first step in SEM is to specify path diagrams of the measurement and structural models based on theory and prior research on the relationships between key variables (44). The measurement model is the part of the model that relates the observed variables to latent variables. The structural model is the part of the model that relates the latent variables to each other. In this study we include both latent and observed variables that are presumed to be associated with them. The relationships in the model were directly translated into equations to facilitate model estimation.

In SEM there are two types of variables those are indicator or observed, manifest variables which are presented in the path diagram by box and latent or construct or factor variables are presented in circle or ovals in the path diagrams. The relationships between variables are indicated by lines. A line with a single arrow represents a direct relationship between two variables and double arrows shows the covariance or correlation of two variables.

As we mentioned in chapter two in the conceptual framework, we have three latent variables such as socioeconomic disadvantage, food insecurity and indoor air pollution. Each latent variable have measured by indicator variables. For the latent variable socioeconomic disadvantage variable the indicators are maternal educational level, wealth index, marital status, and type of residence. For food insecurity latent variable we have eight items to measure the food security situation of a mother. Indoor air pollution was measured by number of fuel used, duration of staying in a cooking area, frequency of cooking per day, frequency of cooking per week and ventilation indicators. For this study we have three measurement models and one structural model is included to study the effect on birth outcomes.

Model formulation for measurement model

For model formulation procedure first we have to go to measurement model and then do for structural model. For this study we have three measurement models and did model formulation independently for each of the three measurements.

Model formulation of socioeconomic disadvantaged mothers

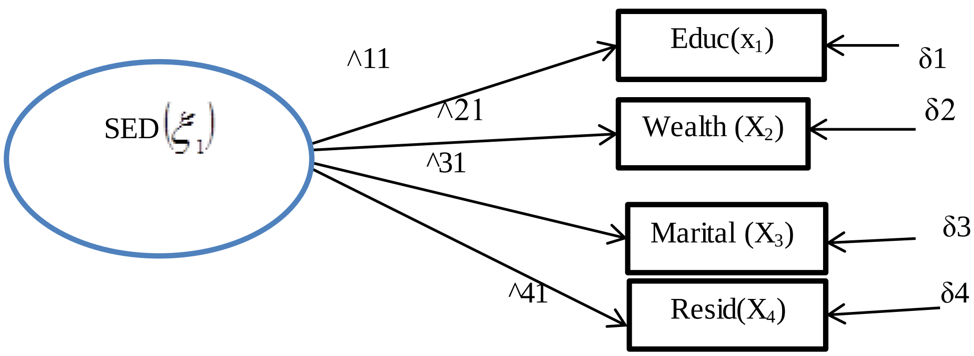


Figure 3.1 Measurement model for socioeconomic disadvantage.

The measurement model for this path diagram was changed into simultaneous equations

$X_1 = \wedge_{11} * \xi_1 + \delta_1$ $X_4 = \wedge_{41} * \xi_1 + \delta_4$

$X_2 = \wedge_{21} * \xi_1 + \delta_2$ $X_3 = \wedge_{31} * \xi_1 + \delta_3$

We can also express in matrix form for the above measurement model.

$$X_{(4x1)} = \wedge_{(4x1)} \ \xi_{1\,(1x1)} + \delta_{(4x1)} \quad [3.1]$$

Measurement model for food insecurity

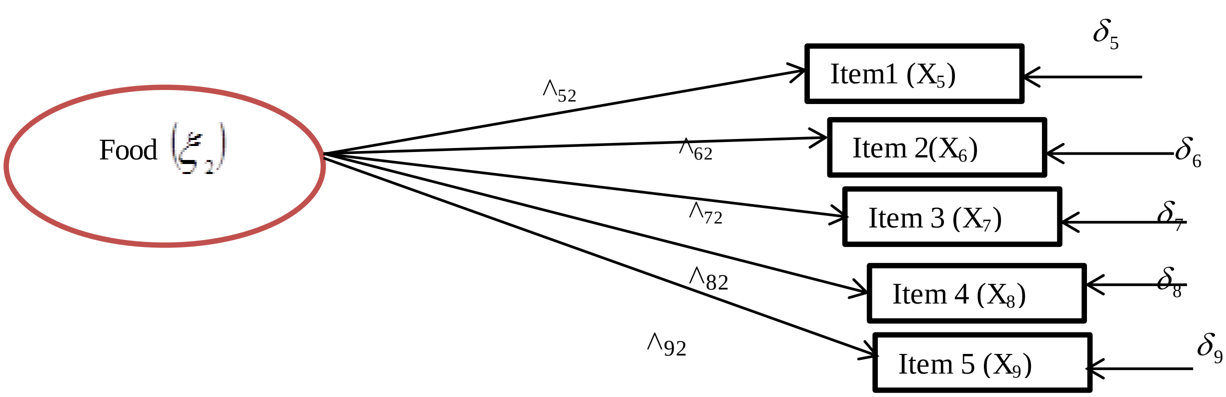


Figure 3.2 Measurement model for food insecurity

The measurement model for this path diagram was changed into simultaneous equations

$X_5 = \wedge_{52} * \xi_2 + \delta_5$ $X_8 = \wedge_{82} * \xi_2 + \delta_8$

$X_6 = \wedge_{62} * \xi_2 + \delta_6$ $X_9 = \wedge_{92} * \xi_2 + \delta_9$

$X_7 = \wedge_{72} * \xi_2 + \delta_7$

We can also express in matrix form

$$X_{(5x1)} = \wedge_{(5x1)} \xi_{2\,(1x1)} + \delta_{(5x1)} \quad [3.2]$$

Measurement model for indoor air pollution

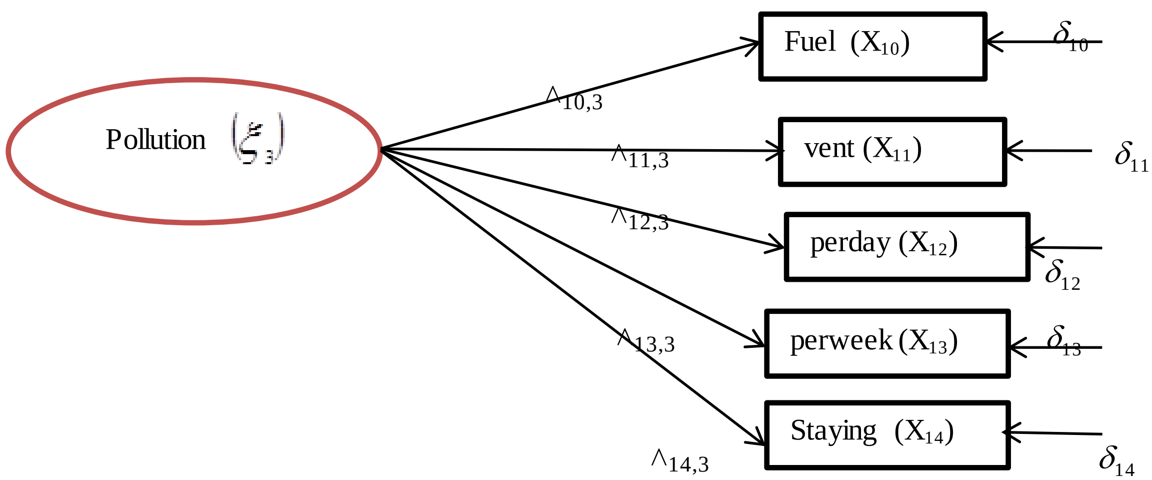


Figure 3.3 Measurement model for indoor air pollution

The measurement model for this path diagram was changed into simultaneous equations

$X_{10} = \wedge_{10,3} * \xi_3 + \delta_{10}$ $X_{13} = \wedge_{13,3} * \xi_3 + \delta_{13}$

$X_{11} = \wedge_{11,3} * \xi_3 + \delta_{11}$ $X_{14} = \wedge_{14,3} * \xi_3 + \delta_{14}$

$X_{12} = \wedge_{12,3} * \xi_3 + \delta_{12}$

So in matrix form

$$X_{(5x1)} = \wedge_{(5x1)} \xi_{3\,(1x1)} + \delta_{(5x1)} \quad [3.3]$$

Then combining equation [3.1], [3.2] and [3.3] of three measurement models in matrix form were

$$
\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ . \\ . \\ . \\ x_{14} \end{bmatrix}_{(14\times1)}
=
\begin{bmatrix} \lambda_{11} & 0 & 0 \\ \lambda_{21} & 0 & 0 \\ \lambda_{31} & 0 & 0 \\ \lambda_{41} & 0 & 0 \\ 0 & \lambda_{52} & 0 \\ . & . & . \\ . & . & . \\ . & . & . \\ 0 & 0 & \lambda_{14,3} \end{bmatrix}_{(14\times3)}
\begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \end{bmatrix}_{(3\times1)}
+
\begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \\ . \\ . \\ . \\ \delta_{14} \end{bmatrix}_{(14\times1)}
$$

$$X_{(14x1)} = \lambda_{(14\times3)}\xi_{(3\times1)} + \delta_{(14\times1)} \qquad [3.4]$$

This is the measurement model written in matrix form.

Model formulation for structural model

In structural equation modeling after formulating the measurement model the next step is model formulation for structural model.

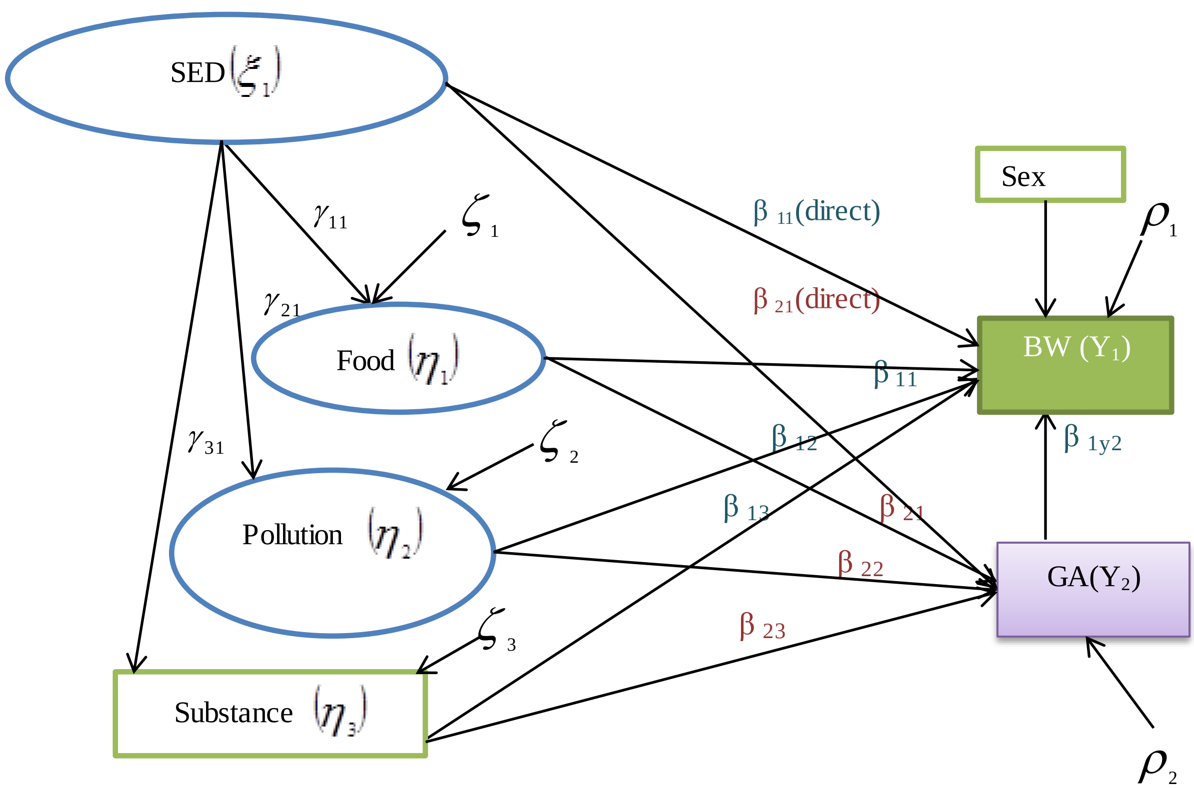


Figure 3.4 Structural models for latent variables and birth outcomes

$$\eta_1 = \gamma_{11}\xi_1 + \zeta_1 \qquad \eta_3 = \gamma_{31}\xi_1 + \zeta_3$$

$$\eta_2 = \gamma_{21}\xi_1 + \zeta_2$$

$$\eta_{(3x1)} = \gamma_{(3x1)}\xi_{(1x1)} + \zeta_{(3x1)} \qquad [3.5]$$

$$Y_1 = \beta_{11}\xi_1 + \beta_{11}\eta_1 + \beta_{12}\eta_2 + \beta_{13}\eta_3 + \beta_{1y2}Y_2 + \rho_1$$

$$Y_2 = \beta_{21}\xi_1 + \beta_{21}\eta_1 + \beta_{22}\eta_2 + \beta_{23}\eta_3 + \rho_2$$

In matrix form

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix}_{(2\times1)} = \begin{bmatrix} \beta_{11} & \beta'_{11} & \beta_{12} & \beta_{13} & \beta_{1y2} \\ \beta_{21} & \beta'_{21} & \beta_{22} & \beta_{23} & 0 \end{bmatrix}_{(2\times5)} \begin{bmatrix} \xi_1 \\ \eta_1 \\ \eta_2 \\ \eta_3 \\ Y_2 \end{bmatrix}_{(5\times1)} + \begin{bmatrix} \rho_1 \\ \rho_2 \end{bmatrix}_{(2\times1)}$$

$$Y_{(2x1)} = \beta_{(2x5)}\eta_{(5x1)} + \rho_{(2x1)} \qquad [3.6]$$

Where $\eta = [\xi_1, \eta_1, \eta_2, \eta_3, Y_2]$

Therefore the overall models for structural equation modeling includes both measurement model and structural model were ([3.4], [3.5], [3.6]);

$$\left.\begin{aligned} X_{(14x1)} &= \lambda_{(14\times3)}\xi_{(3\times1)} + \delta_{(14\times1)} \\ \eta_{(3\times1)} &= \gamma_{(3\times1)}\xi_{(1\times1)} + \zeta_{(3\times1)} \\ Y_{(2x1)} &= \beta_{(2x5)}\eta_{(5x1)} + \rho_{(2x1)} \end{aligned}\right\} \text{This is the SEM model.}$$

Where

$\eta = [\xi_1, \eta_1, \eta_2, \eta_3, Y_2]$

Alternatively, we can express in another form. The model was formulated in the following way.

	η_1	η_2	η_3	ξ	Y_2	ζ_1	ζ_2	ζ_3	ρ_1	ρ_2
η_1	0	0	0	$\gamma_{11}\xi$	0	ζ_1	0	0	0	0
η_2	0	0	0	$\gamma_{21}\xi$	0	0	ζ_2	0	0	0
η_3	0	0	0	γ_{31}	0	0	0	ζ_3	0	0
Y_2	$\beta_{21}\eta_1$	$\beta_{22}\eta_2$	$\beta_{23}\eta_3$	$\beta'_{21}\xi$	0	0	0	0	0	ρ_2
Y_1	$\beta_{11}\eta_1$	$\beta_{12}\eta_2$	$\beta_{13}\eta_3$	$\beta'_{11}\xi$	$\beta_{y1}Y_2$	0	0	0	ρ_1	0

So we can write in matrix form

$$\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ Y_2\\ Y_1\end{bmatrix}_{(5\times1)} = \begin{bmatrix}0 & 0 & 0 & \gamma_{11} & 0\\ 0 & 0 & 0 & \gamma_{21} & 0\\ 0 & 0 & 0 & \gamma 31 & 0\\ \beta_{21} & \beta_{22} & \beta_{23} & \beta'_{21} & 0\\ \beta_{11} & \beta_{12} & \beta_{13} & \beta'_{11} & \beta y1\end{bmatrix}_{(5\times5)} \begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \xi\\ Y_2\end{bmatrix}_{(5\times1)} + \begin{bmatrix}\zeta_1\\ \zeta_2\\ \zeta_3\\ \rho_2\\ \rho_1\end{bmatrix}_{(5\times1)}$$

$$Y_{(5\times1)} = \beta_{(5\times5)}\eta_{(5\times1)} + \rho_{(5\times1)}$$

Therefore the structural equation modeling was

$$\left.\begin{aligned} X_{(14\times1)} &= \lambda_{(14\times3)}\xi_{(3\times1)} + \delta_{(14\times1)}\\ Y_{(5\times1)} &= \beta_{(5\times5)}\eta_{(5\times1)} + \rho_{(5\times1)}\end{aligned}\right\} \quad \text{This is the SEM model.}$$

3.12.2 Model identification

Before model estimation is done it is fundamental to do model identification. Model identification concerns whether a unique value for each and every unknown (free) parameter can be estimated from the observed data. To estimate the unknown or the free parameter first find the data points. The data points are the number of distinct elements in the observed covariance matrix. The following formula is used to calculate the number of data points.

$$k = \frac{p(p+1)}{2}$$

Where p was the number of observed variables and k was the number of data points.

For model identification we have necessary and sufficient conditions. The necessary condition is depending on the number of data points and the number of free parameters in the model. The free parameters in SEM model are factor loadings, factor covariance, path coefficients, residual covariance and the error variances that are to be estimated in the model. If there are more data points than free parameters, the model is said to be over-identified. If the data points are equal to free parameters then the model is said to be just-identified. If the data points are less than the number of free parameters, the model is said to be under-identified and parameters cannot be estimated because it is not possible to estimate more unknowns than there are known. If the above two conditions that is over-identified and just- identified are necessary condition but it is not a sufficient condition. A sufficient condition is very difficult to check.

Over all the best way to solve identification problem is to specify a model correctly and add more indicator variable to the model. Model identification is also depends on the specification of the parameter as free, fixed or constrained. A free parameter is a parameter that is unknown and needs to be model estimated. A fixed parameter is a parameter that is fixed to a specified value. A constrained parameter is a parameter that is unknown but is constrained to equal one or more other parameters. By doing x_1 and x_2 have the same effect on a dependent measure; one may constrain their path coefficients equal in the SEM model. By fixing or constraining some of the parameters, the number of free parameters can be reduced; as such, an under-identified model may become identified (44, 47).

3.12.3 Model estimation

After the model is identified the next step is model estimation. Maximum likelihood (ML) estimation in SEM is simultaneous, which means that the estimates of model parameters are calculated all at once but ML in other traditional models they analyze only a single equation at a time (47). The estimation of SEM model is different from that of multiple regressions that is instead of minimizing the fitted and observed values of the response variable SEM estimation procedures minimize the residuals that are differences between the sample variance/covariance and the variance/covariance estimated from the model. Let us use Σ to denote the population covariance matrix of observed variables y and x; Σ can be expressed as a function of free parameters θ in a hypothesized model. The basic hypothesis in SEM is:

$$\Sigma = \Sigma(\theta)$$

Where $\Sigma(\theta)$ is the model implied variance/covariance matrix; that is, the variance/covariance matrix implied by the population parameters for the hypothesized model. The purpose of model estimation or model fit is to find a set of model parameters θ to produce $\Sigma(\theta)$ so that $\Sigma - \Sigma(\theta)$ can be minimized. The discrepancy between Σ and $\Sigma(\theta)$ indicates how well the model fits the data. Because both Σ and $\Sigma(\theta)$ are unknown, S-$\Sigma\left(\hat{\theta}\right)$ or (S- $\hat{\Sigma}$) is actually minimized in SEM where S is the sample covariance matrix, $\hat{\theta}$ are the model parameter estimates, and $\Sigma\left(\hat{\theta}\right)$ or $\hat{\Sigma}$ is the model estimated/implied covariance matrix. The matrix of observed variance/covariance (S) is used to estimate values for the free parameters in the matrices that best reproduce the data. If the model is correct, $\hat{\Sigma}$ would be very close to S. This estimation process involves the use of a particular fitting function to minimize the difference between S and $\hat{\Sigma}$. There are many fitting functions or estimation procedures available for model estimation. The most commonly employed fitting function for SEM is the maximum likelihood (ML) function and weighted least square (WLS) fitting function. If our observed variables are continuous then we used maximum likelihood estimation.

Let Y~$N_p(0, \Sigma)$

$$f(y_i) = \frac{1}{(2\pi)^{\frac{p}{2}}|\Sigma|^{\frac{1}{2}}} e^{-\frac{1}{2}\left(y_i^T \Sigma^{-1} y_i\right)} \quad i = 1,2,......,n \qquad [3.7]$$

$$L(\Sigma) = f(y_1, y_2, ..., y_n) = \prod_{i=1}^{n} f(y_i) = \frac{1}{(2\pi)^{\frac{np}{2}}|\Sigma|^{\frac{n}{2}}} e^{-\frac{1}{2}\sum_{i=1}^{n}\left(y_i^T \Sigma^{-1} y_i\right)}$$

$$\ln L(\Sigma) = \frac{-np}{2}\ln(2\pi) - \frac{n}{2}\ln|\Sigma| - \frac{1}{2}\sum_{i=1}^{n}\left(y_i^T \Sigma^{-1} y_i\right) \qquad [3.8]$$

$\frac{-np}{2}\ln(2\pi)$ is independent from the parameter $\sum$ we remove from [3.8]

$$\ln L(\Sigma) = -\frac{n}{2}\ln|\Sigma| - \frac{1}{2}\sum_{i=1}^{n}\left(y_i^T\,\Sigma^{-1}\,y_i\right) \qquad [3.9]$$

$$\ln L(\Sigma) = -\frac{n}{2}\ln|\Sigma| - \frac{n}{2}\sum_{i=1}^{n}\frac{1}{n}\left(y_i^T\,\Sigma^{-1}\,y_i\right) \qquad [3.10]$$

$$\ln L(\Sigma) = -\frac{n}{2}\ln|\Sigma| - \frac{n}{2}tr\left(\frac{1}{n}y_i^t y_i\,\Sigma^{-1}\right) \qquad [3.11]$$

$$\ln L(\Sigma) = -\frac{n}{2}\ln|\Sigma| - \frac{n}{2}tr\left(S\,\Sigma^{-1}\right) \qquad [3.12]$$

$$\ln L(\Sigma) = -\frac{n}{2}(\ln|\Sigma| + tr\left(S\,\Sigma^{-1}\right)) \qquad [3.13]$$

From the model

$$\operatorname{cov}(Y) = \Sigma = \lambda\phi\lambda^T + \theta_\delta \qquad [3.14]$$

And we assume that

$S_{(p+q)(p+q)} = \Sigma_{(p+q)(p+q)}$ We assume that the variance/covariance matrix of the population is equal to the sample variance /covariance matrix.

$$\ln L(S) = -\frac{n}{2}(\ln|S| + tr\left(SS^{-1}\right)) \qquad [3.15]$$

$$\ln L(S) = -\frac{n}{2}(\ln|S| + tr(I)) \qquad [3.16]$$

Because tr(I) is the diagonal elements of sample covariance S which is p+q

$$\ln L(S) = -\frac{n}{2}(\ln|S| + (p+q)) \qquad [3.17]$$

Then to find the parameter of the model we were going to minimize the difference between [3.13] and [3.17] say F(Θ).

$$F(\theta) = \ln L(s) - \ln L(\Sigma) \qquad [3.18]$$

$$F(\Theta) = -\frac{n}{2}(\ln|S| + (p+q)) + \frac{n}{2}(\ln|\Sigma| + tr\left(S\,\Sigma^{-1}\right)) \qquad [3.19]$$

$$F(\Theta) = \frac{n}{2}[(\ln|\Sigma| + tr\left(S\,\Sigma^{-1}\right)) - \ln(S) - (p+q)] \qquad [3.20]$$

By ignoring the constant

$$F_{ML}(\Theta) = \ln|\Sigma| + tr(S\,\Sigma^{-1}) - \ln(S) - (p+q) \qquad [3.21]$$

This is the equation which we want to minimize using Newton Raps on method or Gauss Newton method to find the free parameters. From [3.21] S and $\sum$ are the sample and model estimated variance/covariance matrices, respectively and (p+q) is the number of observed variables involved in the model. When a model fit perfectly the model variance/covariance equals the sample variance/covariance matrix. That is $F_{ML}(\Theta)$=0 a perfect model fit(44).

The WLSMV is the robust WLS method. It uses only the diagonal of weights to estimate parameters, and all weights in estimation of fit and standard error whereas WLS uses the full weight to estimate parameters. As opposed to WLS, this method can be used with small sample sizes, large models, as well as skewed and ordinal data. It is also a distribution free estimator. It uses the asymptotic variance from the asymptotic covariance matrix for the diagonal weight and full weight.

The above fit function [3.21] worked when all dependent variables are continuous as well as if the variable is ordinal then their categories must be five and above and fulfill multivariate normality otherwise it is not a robust estimator.

In maximum likelihood estimation methods the covariance matrix of the sample S is used to estimate the covariance structure $\sum(\theta)$. However, in WLSMV estimator analyze the correlation matrices rather than the covariance matrices of the sample. The estimation of the model parameters using WLSMV is done in three steps. The first step involves estimating the threshold using the ML estimation method and the second step involves estimating the correlation matrices of the observed variables using poly choric, poly serial, bi-serial and Pearson correlation given the thresholds. The ML method used only the Pearson correlation whereas WLSMV uses the above correlation including Pearson correlation. Poly choric correlation is obtained when the correlation between ordinal and ordinal dependent variables and poly serial correlation is the correlation between ordinal and continuous variables whereas bi-serial correlation the correlation between binary and continuous variables. The Pearson correlation is the correlation between two continuous variables.

The last step in WLSMV estimates the parameters of the model by mean and variance adjusted weighted least square using a diagonal weight matrix which is an estimate of the asymptotic covariance matric of the correlations estimated in the second step. Full weight matrices are used to estimate the standard errors and the chi-square test.

The fit function for WLS/WLSMV were

$$F_{WLS}(\theta) = (S-\sigma)^T W^{-1}(S-\sigma) \quad [3.22]$$

Where T indicates transposition and W is a weight matrix.

$$S^T = (S_{11}, S_{12}, \ldots, S_{pp}) \quad [3.23]$$

$$\sigma^T = (\sigma_{11}, \sigma_{12}, \ldots, \sigma_{pp}) \quad [3.24]$$

Where S contains the threshold, the correlation and the parameter estimates, mean and variances continuous variables of the sample and σ is the model estimated parameters. W is a consistent estimate of the asymptotic covariance matrix of S. This WLSMV estimate is obtained by means of iterative procedure that minimizes a fit function [3.22] by successively improving the parameter estimates.

In this study ordinal such as wealth index, education, marital status etc. and continuous dependent variables such as birth weight and gestational age are included. Some ordinal variables have below five category and others are five and above category that is set by the MPLUS program. So the choice of the estimator by looking the variable is difficult. Though, comparison of ML and WLSMV estimators were performed through their fit indices that available in both ML and WLSMV estimator. The fit indexes available and common in the two estimators are chi-square test/df, CFI, TLI, and RMSEA. Depending on the fit indices we select the best estimator from the two estimators and parameters were estimated using the selected estimator(44, 48).

3.12.4 Model fit

Once the model has been developed we would like to know how effective the model is to assess the degree of the model estimated covariance matrix differs from the observed sample covariance matrix. If the model estimated covariance matrix is not statistically different from the observed data covariance matrix, then we say that the model fits data well, and the model supports the plausibility of formulated relations among the variables; otherwise the model does not fit the data, and the null hypothesis should be rejected.

There are two types of model fit indices. These are absolute fit index and relative fit index. The chi-square and RMSEA fit indices are an absolute fit index while CFI, TLI and WRMR were relative fit index.

1. **The chi-square test :** The χ^2 statistic is the original fit index for structural models, which is defined as

$\chi^2 = (N-1)F_{ML}$ Follows a χ_v^2 where v is the degree of freedom for chi-square difference between the data point and free parameter.

Where $F_{ML} = f\left(S, \hat{\Sigma}\right)$ is the minimum value of the fitting function for the specified model and N is the sample size. This product is distributed χ^2 as if the data are multivariate normal, and the specified model is correct. The χ^2 statistic assesses the magnitude of the discrepancy between the sample and the model estimated covariance matrices. Lower and non-significant χ^2 value was desired for good model fit. That is, we expect the test not to reject the null hypothesis (H0: the residual matrix is zero or there is no difference between the model estimated covariance and the observed sample covariance). However, the chi-square test is sensitive to both sample size and model size, and can lead to the inappropriate rejection of the plausible models. Therefore, chi-square divided by the degree of freedom was used as an index of model fit. Generally, values lower than 3 indicated a good fit(44).

When at least one dependent variable treated as binary or ordered categorical the typical procedure of calculating the difference between chi-squares for an unconstrained and fully constrained model needs to be modified because the difference in chi-square for two nested models using the mean and variance adjusted WLSMV estimator of the chi-square values is not distributed as chi-square. Therefore in order to obtain a correct chi-square difference test for WLSMV, a two-step procedure is needed, one that saves the derivatives from the less restrictive model in order to compare them to the derivatives from the fully constrained model for computing the chi-square difference(48).

2. **Comparative fit index (CFI):** It compares the specified model with the null model which assumes zero covariance among the observed variables.

$$CFI = 1 - \frac{\chi_v^2 - v}{\chi_0^2 - v_0}$$

Where v is the degree of freedom for chi-square obtained for the full model by difference between the data point and free parameter in the model. The value of CFI ranges from 0 to 1. A CFI value greater than or equal to 0.90 is desirable. Analogous to R^2, CFI=0 indicates the worst fit and CFI=1 indicates the best fit(44).

3. **Tucker-Lewis Index (TLI):** The TLI is another way of comparing the lack fit of the specified model to the lack fit of the null model. TLI is defined as;

$$\textbf{TLI=}\frac{\left(\frac{\chi^2_{null}}{df_{null}} - \frac{\chi^2_{specified}}{df_{specified}}\right)}{\left(\frac{\chi^2_{null}}{df_{null}} - 1\right)}$$

Where χ^2_{null}/df_{null} and $\chi^2_{specified}/df_{specified}$ are ratios of χ^2 statistics to the degrees of freedom of the null model and the specified model respectively. The value of the TLI ranges from 0 to 1. A TLI value greater than or equal to 0.90 is desirable(44).

4. **Root mean square error of approximation (RMSEA):** RMSEA is one of the most recently proposed tests of model fit. The error of approximation means the lack of fit of the specified model to the population. The RMSEA is defined as:

$$RMSEA = \sqrt{\frac{(\chi_s^2 - df_s)/N}{df_s}} = \sqrt{\frac{((\chi_s^2)/df_s) - 1}{N}}$$

Table 3.1The cut-off value of RMSEA

RMSEA	CONDITION OF FIT
0	Perfect fit
<0.05	Close fit
0.05-0.08	Fair fit
0.08-0.10	Moderate fit
>0.10	Poor fit

5. **Weighted root mean square residual (WRMR); -** is defined as

$$WRMR = \left(\frac{\sum_j \sum_k (s_{jk} - \sigma_{jk}) / v_{jk}}{e} \right)^{\frac{1}{2}}$$

Where S_{jk}-σ_{jk} is the residual, V_{jk} is the estimated asymptotic variance of S_{jk}, and e is the total number of sample variances and covariance's. WRMR is more suitable for models where sample statistics have large disparate variances, outcome measures have non-normal distributions, and when sample statistics are on different scales such as in models with mean and or threshold structures. AWRMR value of 1.0 or lower is considered as a good fit(44).

3.12.5 Comparison of Nested Models

In addition to evaluating the overall model fit and specific parameter estimates, it is also possible to statistically compare nested models to one another. Nested models are models that are subsets of one another. The model which had a more parameter or few degrees of freedom is considered as a full model and a model which had few parameters or more degree of freedom was taken as nested model. To do a comparison the chi-square difference test was applied. If the chi-square difference is significant, then the fuller model was retained and taken as a final model. On the other hand if the difference is not significant the nested model which was more parsimonious than the full model would be accepted as a preferred model.

3.12.6 Model modification

The initial model of SEM may not always fit data well. In such case, the possible source of lack of model needs to be assessed and modify the wrong model formulation and re-test it using the same data. This is done using fixing, freeing, constrain, dropping variables and adding paths to the correlated variables and then we re-run the model and look the model fit on the same data.

4 Result and Discussion

4.1 Descriptive analysis

Before doing any data analysis, the data set was prepared and preliminary analysis was under taken to identify any issues that might have impact on the analysis. Screening the data was done for univariate outliers using box and whisker plot and the issue of non- normality is not a concern here because we used weighted least square mean and variance adjusted estimators which had no distributional assumptions.

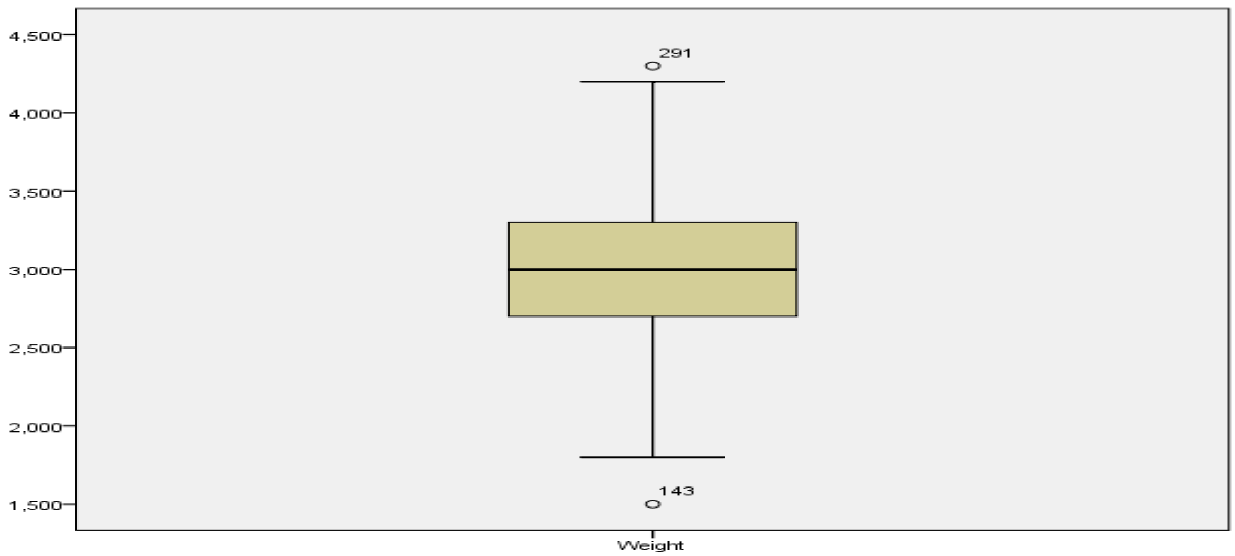


Figure 4.1 Box and whisker plot of birth weight to check outliers.

As seen from the figure 4.1 there is no outliers for the outcome variable birth weight.

Table 4.1 Descriptive statistics for variables in the study

Variables	Range/value	Mean(SD)or % (N=421)
Age	16-43	26.29(5.138)
Gestational age at birth (weeks)	26-46	38.8(2.332)
Birth weight (gram)	1500-4300	2962.47 (477.361)
LBW (yes)	-	13.5%
PTB (yes)	-	15.0%
Delivery		
Gondar	1	42%
Bahir Dar	2	58%
Sex of the infant		
Male	0	58.9%
Female	1	41.1%
Maternal education		
Illiterate	1	25.8%
Primary	2	29.0%
Secondary	3	25.7%
Above secondary	4	19.5%
Religion		
Orthodox	1	86.9%
Muslim	2	11.4%
Others	3	1.7%
Residence		
Urban	0	67%
Rural	1	33%
Alcohol use(yes)	-	38.0%
Drug use (yes)	-	18.1%

SD =standard deviation

Table 4.3 presents descriptive statistics for the study sample. The age of the mother during delivery ranges from 16 years to 43 years. The mean age of the women during delivery was 26.29 years, most of them (67%) living in urban areas and 25.9% of them were illiterate. Among the new born infants in the sample, birth weights ranged from 1500 grams to 4300 grams (mean=2962.47, SD = 477.361), and gestational ages ranged from 26 weeks to 46 weeks (mean = 38.8, SD = 2.332). When dichotomized, these data translated into a LBW rate of 13.5% and PTB rate of 15.0%. The prevalence of both outcomes in this sample was higher than the previous studies.

Approximately 42% of women in the sample were delivered in Gondar referral teaching hospital and 58% were women delivered Bahir Dar Felege Hiwot referral hospital. 38% of the women they drink alcohol during their pregnancy period and approximately eighteen percent of the women they took illicit drugs during this pregnancy.

Table 4.2 Bivariate association between birth outcomes and factors treated as a control variables

Variables	Gestational age			Birth weight		
	β [a]	(95% CI)	P-value	β [a]	(95% CI)	P-value
Antenatal care	0.487	(0.358,0.617)	0.000	123.24	(77.56-148.94)	0.000
Residence						
Urban	-------	---------	-----	------	--------------	-----
Rural	-0.884	(-1.351,-0.416)	0.000	-160.93	(-257.05,-64.80)	0.001
Sex						
Male	-------	--------	------	-------	-----------	------
Female	-0.093	(-0.361,-0.547)	0.669	-104.09	(-196.61,-11.565)	0.028

a Regression coefficients are unstandardized

Table 4.5 shows unadjusted bivariate associations between birth outcomes and the factors treated as control variables because of their known or suspected relationship to birth outcomes. Being living in rural area and sex of the infant were correlated with significantly lower birth weight but not with gestational age for sex. Delivery site and age of the women are not significantly correlated with birth outcomes. However a mother who followed antenatal care during pregnancy had a positive significant association between birth outcomes.

Table 4.3 Bivariate association between birth outcomes and indicators of different latent variables.

Variables	Gestational Age(week)			Birth weight(grams)		
	β [a]	**(95% CI)**	**P-value**	**β [a]**	**(95% CI)**	**P-value**
Socioeconomic disadvantage indicators						
Wealth index						
Quintile 1	-1.430	(-1.98,-0.89)	0.000	-416.83	(-525.29,-308.37)	0.000
Quintile 2	-0.405	(-0.96,1.53)	0.154	29.038	(-85.49, 143.70)	0.618
Quintile 3	-0.670	(-1.221,-0.119)	0.012	-249.56	(-357.63,-135.49)	0.000
Quintile 4	0.788	(0.240,1.335)	0.005	213.92	(102.72,325.12)	0.000
Quintile 5	1.717	(1.177,2.257)	0.000	419.17	(310.17, 527.55)	0.000
Education						
Illiterate	-1.192	(-1.689,-0.694)	0.000	-303.41	(-403.79,-203.03)	0.000
Primary	-0.354	(-0.846,0.138)	0.158	-27.95	(-128.83, 72.44)	0.586
Secondary	0.804	(0.298,1.31)	0.002	183.74	(80.39, 287.08)	0.001
Above second	0.944	(0.387,1.502)	0.001	184.43	(70.18, 298.68)	0.002
Marital status						
Not married	-1.520	(-2.268,-0.771)	0.000	-450.25	(-600.20,-300.21)	0.000
Married	-----	--------	------	------	---------	-------
Indoor air pollution indicators						
perday	-0.823	(-1.114,-0.532)	0.000	-332.29	(-385.123,-279.46)	0.000
perweek	-0.358	(-0.472,-0.243)	0.000	-160.45	(-179.536,-141.359)	0.000
Staying	-1.160	(-1.607,-0.713)	0.000	-365.91	(-453.44,-278.37)	0.000
Number of fuel	-0.691	(-0.968,-0.413)	0.000	-301.58	(-352.32,-250.84)	0.000
Food insecurity measured by eight indicators						
Food in. score	-0.390	(-0.485,-0.295)	0.000	-121.67	(-138.995,-104.344)	0.000

Abbreviation: perday=the frequency of cooking food per day; perweek= the frequency of cooking food per week. Staying= staying in a cooking area; fuel= the number of fuel used for cooking.

a **Regression coefficients are unstandardized**

Before doing any measurement model to examine the relationship between the constructs and the indicators we did first unadjusted bivariate association between birth weight and gestational age and the observed variables to get preliminary overview of whether or not the data were consistent with the research findings.

Table 4.6 presents unadjusted bivariate association between birth outcomes and indicators of latent variables. Unadjusted bivariate analysis revealed that four of the five wealth quintiles were significantly associated with gestational age and birth weight. A house hold Being in the second quintile is not statistically significant with gestational age and birth weight (β=-0.405,p=0.154 and β=29.038, p=0.618) respectively. A mother falls in the first quintile decreases 1.43 weeks of gestational age and decrease 416.83 gram of birth weight as compared to the other mother who falls in the remaining quintiles. However, a mother in the fifth quintile increase 1.717 weeks of gestational age and an increase of 419.17 gram of birth weight as compared to that of the remaining quintiles with (p=0.000 and p=0.000) respectively.

A mother who has a primary education had no significant relationship with birth outcomes. On the other hand a mother having no education had a decrease in 1.192 weeks of gestational age and a decrease in 303.41 grams of birth weight when compared to women who had other educational levels. On the other hand, having a mother with educational level beyond high school was associated with an increase of roughly 184.43 grams in infant birth weight when compared to women who had in other educational levels.

All indicators of indoor air pollution were significantly associated with gestational age and birth weight. The scores of food insecurity were also significantly associated with birth outcomes.

4.2 Model identification of structural equation modeling

Prior to doing any measurement and structural model analysis it was better to compare the number of data points and the number of free parameters to be estimated by the model. To be a model testable, the model needed to have fewer parameters than the data points. The following formula was used to calculate the number of data points.

$$k = \frac{p(p+1)}{2}$$

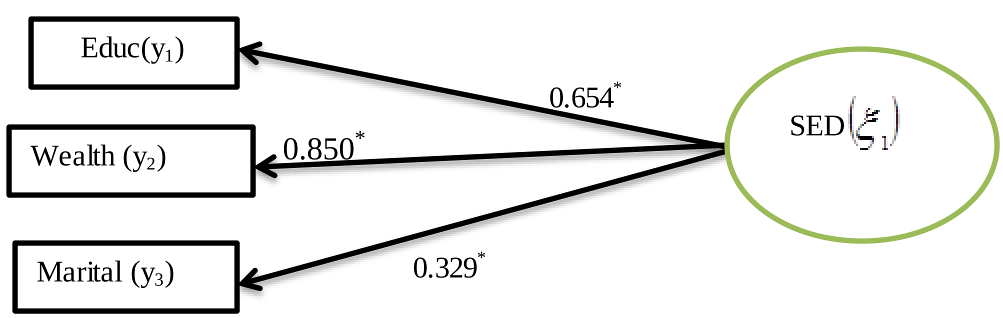
Where p was the number of observed variables and k was the number of data points. For this study we have 15 observed variables and the data points are as follow

$$k = \frac{15(15+1)}{2} = 120$$

This satisfied the requirement to exceed the 59 parameters for the model. So we can say that the model was over identified (having more data points than parameters).

4.3 Measurement model for socioeconomic disadvantage

The original model of the measurement model of socioeconomic disadvantage showed that the standardized factor loadings were statistically significant. However, the goodness of model fit was not meet the minimum requirements especially for RMSEA and WRMR were above the minimum requirement and highly significant chi-square statistic (χ^2(4)=36.378 p=0.000 CFI=0.999 TLI=0.997 RMSEA=0.139 and WRMR=1.1167). This leads us some modification on the measurement model of socioeconomic disadvantage. To get a good model fit we tried to avoid residence variable from the conceptual frame work of the measurement model and we have to re-run our measurement model again. This change resulted in, high improvement on the model fit and all the fit index measures especially RMSEA and WRMR improved very well. On the other hand, the chi-square value remained statistically significant (χ^2(0)=0.000 p=0.000 CFI=1.00 TLI=1.00 RMSEA=0.000 and WRMR=0.000). This final model of socioeconomic disadvantage measurement model is presented in Figure 4.3 with standardized regression coefficients. All factor loadings for the model were statistically significant at the $p \leq .05$ levels. In addition, the magnitude of the factor loadings were moderately to very high for all indicators (i.e., $\geq$ 0.30), as well as the R-square values for the indicators (i.e., $\geq$ 0.10). The indicator with the highest loading for this construct was wealth index. This indicates that the latent variable, socioeconomic disadvantage adequately predicted the variability of the wealth index variable.

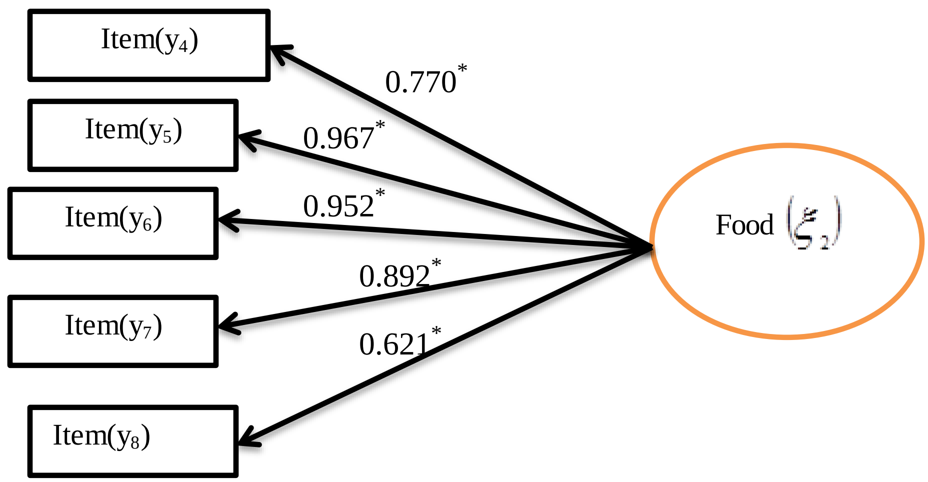


*** Significant at p=0.05**

Figure 4.2 Final standardized measurement models for socioeconomic disadvantage

4.4 Measurement model for food insecurity

The original model of the measurement model of food insecurity showed that the standardized factor loadings were statistically significant as well as the goodness of model fit was very good ($\chi^2(4)=10.738$ p=0.0297 CFI=0.991 TLI=0.991 RMSEA=0.063 and WRMR=0.501). The final model of food insecurity measurement model was presented in Figure 4.5 with standardized regression coefficients. All factor loadings for the model were statistically significant at the $p \leq .05$ levels. In addition, the magnitude of the factor loadings were moderately to very high for all indicators (i.e., ≥ 0.60), as well as the R-square values for the indicators (i.e., ≥ 0.30).



***Significant at p=0.05**

Figure 4.3 Final standardized measurement models for food insecurity

4.5 Measurement model for indoor air pollution

The original model of the measurement model of indoor air pollution showed that the standardized factor loadings were statistically significant. However, RMSEA fit value was above the cut of value ($\chi^2(5)=25.233$, p=0.0001, CFI=0.963, TLI=0.948, RMSEA=0.098 and WRMR=0.732). This leads us some modification on the measurement model of indoor air pollution. To get a good model fit I tried to avoid ventilation variable from my conceptual frame work of our measurement model and we re-run our measurement model again. This change, resulted in high improvement on the model fit and all the fit index measures especially chi-square statistic improved very well and the chi-square value statistically insignificant as well as the RMSEA was also improved ($\chi^2(2)=5.632$ p=0.0598 CFI=0.992 TLI=0.980 RMSEA=0.066

and WRMR=0.411). The fit indices satisfy the cut-off point. Hence, we take as final model of indoor air pollution. This final model of indoor air pollution measurement model is presented in Figure 4.4 with standardized regression coefficients. All factor loadings for the model were statistically significant at the $p \leq .05$ levels. In addition, the magnitude of the factor loadings were moderately to very high for all indicators (i.e., ≥ 0.40), as well as the R-square values for the indicators (i.e., ≥ 0.16). The indicator with the highest loading for this construct was the frequency of cook per week. This indicates that the latent variable indoor air pollution adequately predicted the variability of this variable.

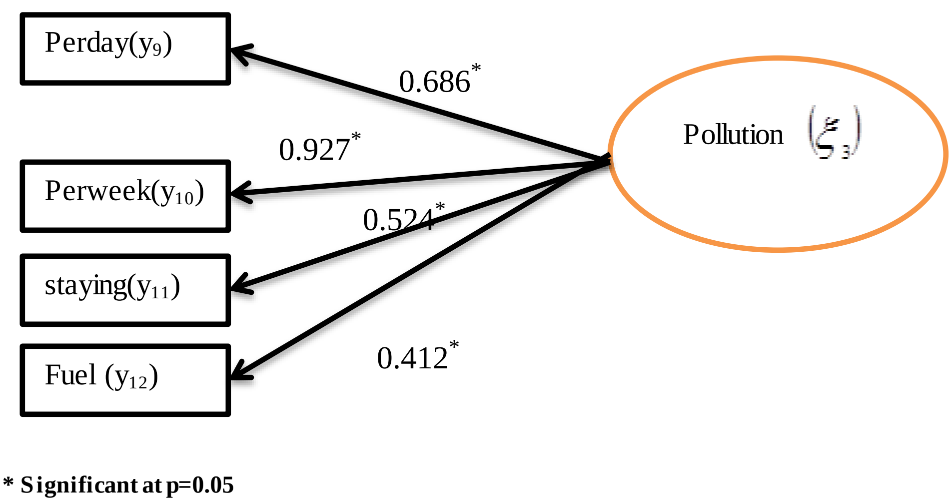


Figure 4.4 Final measurement model for indoor air pollution with their standardized factor loadings

Table 4.4 Final fit statistics for the final measurement model with their factor loadings.

Latent variables	Observed indicators	Factor loadings		R^2
		unstandardized	standardized	
Socioeconomic disadvantage				
χ^2(0)=0.0000 **P=0.000** **CFI=1.00** **TLI=1.00** **RMSEA=0.000** **WRMR=0.000**	Marital status Wealth index Education	1.00* 2.585 1.990	0.329 0.850 0.654	0.108 0.722 0.428
Food insecurity				
χ^2(2)=10.738 **P=0.0297** **CFI=0.991** **TLI=0.991** **RMSEA=0.063** **WRMR=0.501**	Item-1 Item-2 Item-3 Item-4 Item-5	1.00 1.256 1.236 1.162 0.314	0.770 0.967 0.952 0.895 0.621	0.593 0.935 0.905 0.801 0.386
Indoor air pollution				
χ^2(2)=5.632 **P=0.0598** **CFI=0.992** **TLI=0.980** **RMSEA=0.066** **WRMR=0.411**	Perday Perweek Staying Fuel	1.00 1.351 0.763 0.600	0.686 0.927 0.524 0.412	0.470 0.859 0.274 0.169

Abbreviations: CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean squared error of approximation; WRMR = weighted root mean squared residual; R^2 =multiple squared correlation; perday=the frequency of cooking food per day; perweek= the frequency of cooking food per week. Staying= staying in a cooking area; fuel= the number of fuel used for cooking.
*** All factor loadings or path coefficients were significant at p≤ .05;**
**** Parameter constrained to 1.00 to scale the construct; constrained parameters were not tested for statistical Significance**

4.6 Goodness fit of Structural model

Once an acceptable fitting measurement models such as socioeconomic disadvantage, food insecurity and indoor air pollution were obtained the next step were fitting full model using structural equation modeling through MPLUS and R. Before interpreting the estimate of the parameter, goodness of fit the structural model must be checked. Otherwise the estimate of the parameter were biased the objective of the study. So the next step was starting from the original model to check assessment of fit of the structural model. The original model that was set at the conceptual frame work were estimated and the goodness of fit statistics except CFI and TLI, the original model has a poor fit (χ^2(128) =389.404, chi-square ratio=3.04, CFI=0.983, TLI=0.986, RMSEA=0.089 and WRMR=1.438). This result suggested that the model needed modification in order to improve the goodness of fit.

Model-1:- The first modification was done when the hypothesized structural model was imposed on the final measurement models developed in the previous section. This was done by removing some paths from the measurement model of the latent variables. From socioeconomic disadvantage latent variables put restriction on residence indicators and from indoor air pollution latent variable put restriction on ventilation indicators then we re-run the structural model again the goodness of fit statistics was still poor fit (χ^2(97) =198.320, chi-square ratio=2.05, CFI=0.955, TLI=0.963, RMSEA=0.062 and WRMR=1.049). Still modification was needed to improve goodness of fit of RMSEA and WRMR.

Model-2:- The second modification was adding a direct path from socioeconomic disadvantage to gestational age and re-run the structural model again, the goodness of fit statistics was still poor fit especially in the RMSEA and WRMR fit indices fit (χ^2(96) =195.277, chi-square ratio =2.03, CFI=0.956, TLI=0.964, RMSEA=0.061 and WRMR=1.041).

Model-3:- The third modification was that added a direct path from socioeconomic disadvantage to birth weight and re-run the structural model again, the goodness of fit statistics was still poor fit especially in the RMSEA and WRMR fit indices fit (χ^2(96) =189.860, chi-square ratio =1.98, CFI=0.959, TLI=0.966, RMSEA=0.060 and WRMR=1.026).

Model-4:- The fourth modification was that added a direct path from socioeconomic disadvantage to birth weight and gestational age and re-run the structural model again, the goodness of fit statistics was still poor fit especially in the WRMR fit indices fit (χ^2(95) =186.977, chi-square ratio =1.97, CFI=0.959, TLI=0.966, RMSEA=0.059 and WRMR=1.017).

Model-5:- The final modification was that added a correlated error to wealth index indicator and education indicator then re-run the structural model again, the goodness of fit statistics was improved (χ^2(94) =161.682, chi-square ratio=1.72, CFI=0.970, TLI=0.975, RMSEA=0.051

and WRMR=0.921). This fit indices indicated that the modified model fulfill the minimum requirements of all the fit indices and this model was taken as the final modified structural model. All the fit indices of the five models were summarized in table 4.8 below.

Table 4.5 Summery of goodness of fit indices for the original and modified structural model

Models	χ^2	df	Chi/df	CFI	TLI	RMSEA	WRMR
Original model	389.404	128	3.04	0.983	0.986	0.089	1.438
Model-1	198.320	97	2.05	0.955	0.963	0.062	1.049
Model-2	195.277	96	2.03	0.956	0.964	0.061	1.041
Model-3	189.860	96	1.98	0.959	0.966	0.060	1.026
Model-4	186.977	95	1.97	0.959	0.966	0.059	1.017
Model-5	161.682	94	1.72	0.970	0.975	0.051	0.921

Abbreviations: CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean squared error of approximation; WRMR = weighted root mean squared residual

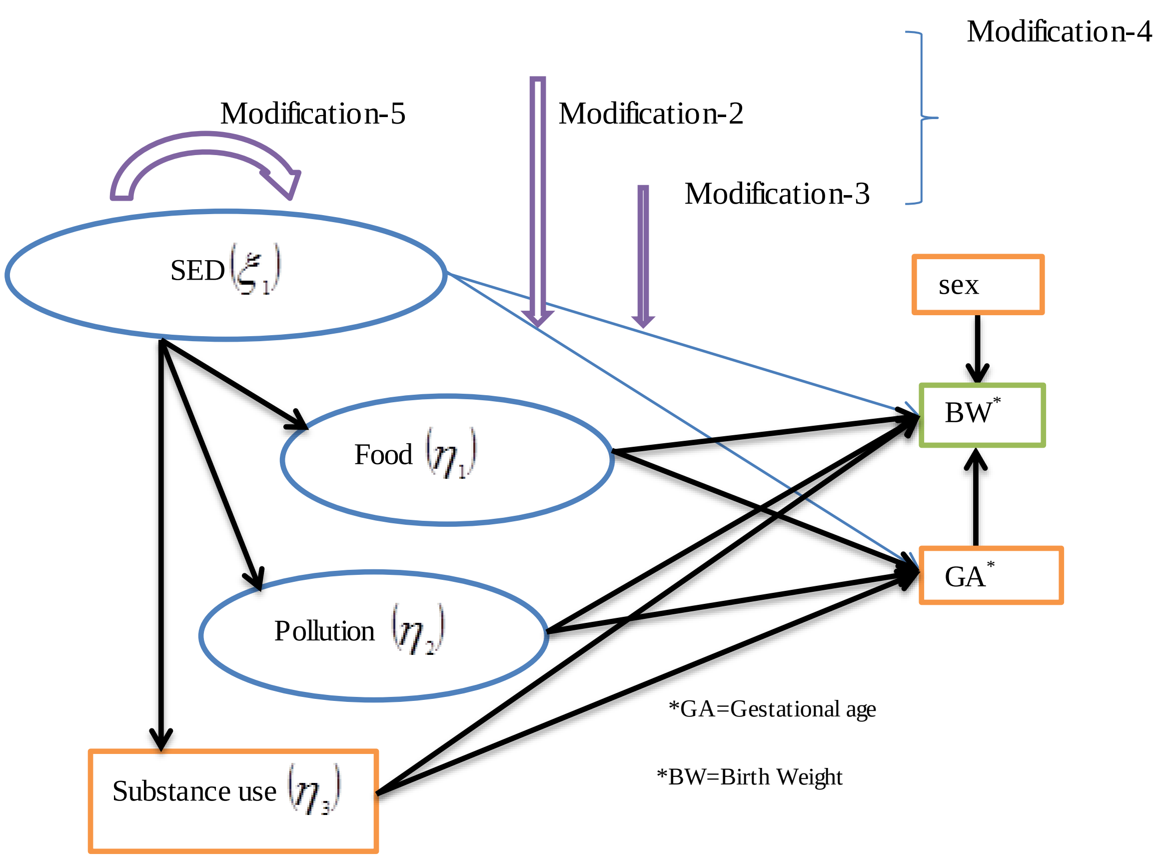


Figure 4.5 Modification of the structural model

The next step was whether the fit of the fifth model, the more relaxed model which had a more free parameter or few degree of freedom were significantly different from the rest of the models(model-1 to model-4) using chi-square differencing test. If the χ^2 difference was a p-value less than 0.05 then the fifth model had a better fit index than the other models and we take as the fifth model as a final model. On the other hand if the χ^2 difference was a p-value greater than 0.05 (insignificant) then the one with the restricted model were taken as a final model. Table 4.9 showed that the fifth model fit the data well than the other models. Because all the chi-square difference tests had a significant p-value.

Table 4.6 The chi-square difference test for model comparison

Relaxed model	Nested model	Chi-square difference	df	p-value	Decision
Model-5	Model-4	17.783	1	0.000	Model-5 better
Model-5	Model-3	26.381	2	0.000	Model-5 better
Model-5	Model-2	19.148	1	0.000	Model-5 better
Model-5	Model-1	29.359	2	0.000	Model-5 better

Df=degree of freedom

Figure 4.7 presents the results of a structural equation modeling analysis of birth outcomes and a different exposure variable in the form of causal network diagram. The variables are represented in boxes and rectangles whereas the arrows between the boxes show the causal influence between those variable and their directions. The arrows are labeled with numbers that can range in size from -1.0 to 1.0 and represents the strength of the relationship. This weight can interpreted in a fashion similar to the standardized beta weights in a multiple regression analysis. Positive coefficients indicate that increases in the variable at the arrowless end of the relationship cause increases in the variable at the arrow end of the relationship. Similarly, negative coefficients shows that increase in the variable at the arrowless end of the variable at the arrow end of the relationship.

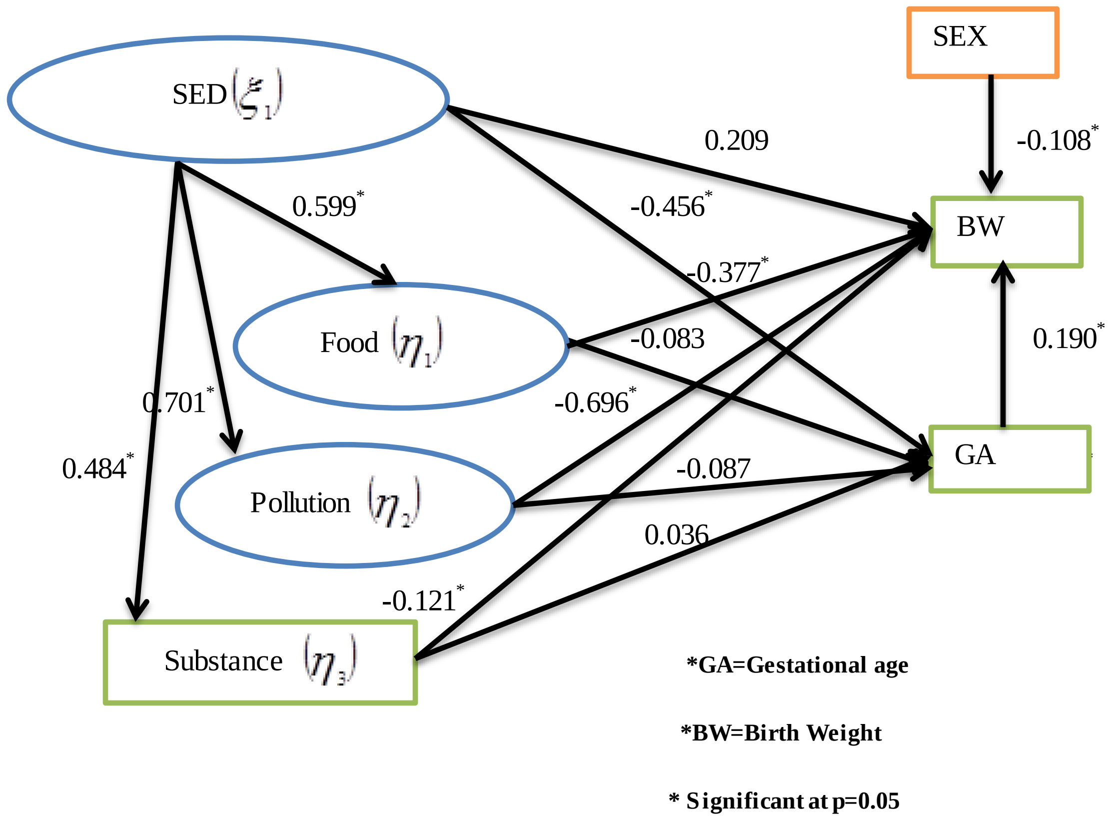


Figure 4.6 Final structural models with standardized coefficients

4.7 Comparison of ML and WLSMV estimators

The comparisons of the two estimators are done using their fit indices. Five model where estimated for each fit index using the ML and WLSMV estimators' separately. Analyses of variance (ANOVA) were done for each fit index between ML and WLSMV estimator and check whether the mean of the fit index between the two estimators are significantly different or not. Based on the fit index we selected the best estimators.

Table 4.7 Fit indices of ML and WLSMV estimators for five models

Estimator	Model	Chi-square value	df	Chi-square/df	CFI	TLI	RMSEA
ML	Model-1	349.882	97	3.61	0.875	0.845	0.079
	Model-2	338.392	96	3.52	0.880	0.850	0.077
	Model-3	341.040	96	3.55	0.879	0.849	0.078
	Model-4	332.766	95	3.50	0.882	0.852	0.077
	Model-5	299.769	94	3.19	0.898	0.870	0.072
WLSMV	Model-1	198.320	97	2.05	0.963	0.955	0.050
	Model-2	195.277	96	2.03	0.964	0.955	0.050
	Model-3	189.860	96	1.98	0.966	0.958	0.048
	Model-4	186.977	95	1.97	0.967	0.958	0.048
	Model-5	161.682	94	1.72	0.976	0.969	0.041
Cut-off Point for Fit index				< 3 acceptable fit	>0.90 Good fit	>0.90 Good fit	0=perfect fit <.05 close fit .05-.08 fair fit .08-.10 moderate fit >0.10 poor fit

df= degree of freedom; **TLI = Tucker-Lewis index; RMSEA = root mean squared error of approximation; CFI=comparative fit index**

Table 4.1 presents the fit indices for the ML and WLSMV estimators for the five models. Results showed that in each model, WLSMV estimator lower fit value for RMSEA and the ratio of chi-square to their degree of freedom fit indices and large fit indices values of CFI and TLI. When considering the first model WLSMV estimator had the ratio of chi-square to degree of freedom is 2.05, CFI=0.963, TLI=0.955 and RMSEA=0.050 and ML estimator have the ratio of chi-square to degree freedom is 3.61, CFI=0.875, TLI=0.845 and RMSEA=0.079. By taking only the fit indices of model-5 the WLSMV estimator had chi-square to the degree of freedom was 1.72, CFI=0.976, TLI=0.969 and RMSEA=0.041 and ML estimator of fit indices for the same model were the ratio of chi-square to degree of freedom were 3.19, CFI=0.898, TLI=0.870 and RMSEA=0.072. Based on the cut-off value of fit indices, all the fit indices of the WLSMV estimator were better than the fit indices of ML estimator.

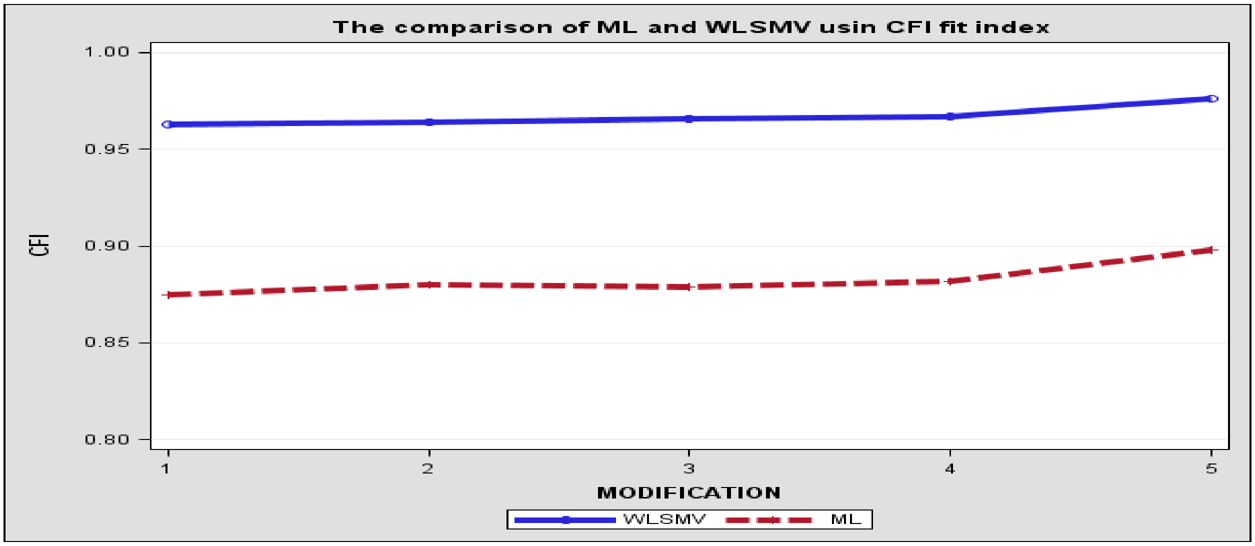


Figure 4.7 The comparison of ML and WLSMV estimators using CFI fit index

As seen from the above figure 4.2 mean and variance adjusted weighted least square were better than maximum likelihood estimator based on the fit index of CFI. The CFI value of the WLSMV estimator is higher than the CFI value of ML estimator. The figures of other fit indices were attached at the **appendix in annex 1.**

Table 4.8 Analysis of variance for each fit indices

Goodness of fit index	Mean of the goodness of fit		
	ML	**WLSMV**	**p-value[a]**
Chi-square/df	3.474	1.950	<0.0001
CFI	0.8828	0.9672	<0.0001
TLI	0.8532	0.9590	<0.0001
RMSEA	0,0766	0.0474	<0.0001

a. Analysis of variance (ANOVA) for the two estimator; df= degree of freedom; TLI = Tucker-Lewis index; RMSEA = root mean squared error of approximation; CFI=comparative fit index.

The comparison between ML and WLSMV estimators were made through their fit indices for five models. ANOVA is applied for each fit indices whether or not the mean of fit indices for the five models between ML and WLSMV estimators are significant or not. Table 4.2 shows that the mean of chi-square to degree of freedom for ML is 3.474 and for WLSMV estimator is 1.950 which were statistically significant ($p<0.0001$). Depending on the cut-off point of fit index chi-square to the degree of freedom the smallest value of the two estimators is best. Hence, based on this WLSMV estimator has the smaller value and better estimator than ML estimator. The means of the CFI and TLI were statistically and significantly different for the WLSMV and ML estimators. WLSMV estimator had the highest CFI and TLI value than ML estimator showed that WLSMV was better than ML estimator. Over all the results of the entire fit index showed that WLSMV estimator are superior to ML estimator for this study. So, all the model parameters of this study were estimated using WLSMV estimator.

Table 4.9 The final structural model of the relationship between exposure variable and birth outcomes

Path	Unstandardized estimates	Standard error**	Standardized Estimate	P*-value
SED → Food	0.882	0.174	0.599	0.000
SED → Indoor	0.851	0.167	0.701	0.000
SED → SUB	0.305	0.064	0.484	0.000
SED → GA	-1.917	0.781	-0.456	0.014
Food → GA	-0.238	0.268	-0.083	0.374
Indoor → GA	-0.300	0.365	-0.087	0.411
SUB → GA	0.241	0.364	0.036	0.508
SED → BW	179.7	1.037	0.209	0.082
Food → BW	-220.6	0.377	-0.377	0.000
Indoor → BW	-490.0	0.564	-0.696	0.000
SUB → BW	-164.8	0.479	-0.121	0.000
GA → BW	38.9	0.078	0.190	0.000
Sex → BW	-104.1	0.479	-0.108	0.030

SED=socioeconomic disadvantage; Food=food insecurity; Indoor=indoor air pollution; SUB=substance use; GA= gestational age; BW= birth weight.
***Significant test for unstandardized coefficient**
**** Standard error for unstandardized coefficients**

Table 4.10 showed there was a statistically significant relationship between socioeconomic disadvantage and exposure variables such as food insecurity, indoor air pollution and substance use during pregnancy. Only socioeconomic disadvantage had a significant effect on gestational age (β=-1.917 p=0.014) and standardized coefficient (β=-0.456). This implied that 0.456 standard deviation decrease in gestational age as a one standard deviation increase in socioeconomic disadvantage. However all the exposure variables are non-significant on gestational age (food insecurity (β=-0.238, p=0.374), indoor air pollution (β=-0.300, p=0.411) and substance use (β=0.241, p=0.508)).

On the other hand socioeconomic disadvantage had a non-significant effect on birth weight (β=179.7, p=0.082) after controlling sex. But food insecurity, indoor air pollution and substance use had a significant effect on birth weight, (food insecurity (β=-220.6 gram, p=0.000), indoor air pollution (β=-490.0gram, p=0.000) and substance use (β=-164.8gram, p=0.001)) respectively. The weight of an infant decreases 220.6gram, 490.0gram and 164.8 gram when a mother exposed to food insecurity, indoor air pollution and substance use respectively after controlling sex. By standardizing the coefficients food insecurity becomes (β=-0.377), indoor air pollution becomes (β=-0.696) and substance use also becomes (β=-0.121). For example, 0.377 standard deviation decreases in birth weight when we increase a one standard deviation increase in food insecurity by controlling sex of the infant. Gestational age also had a significant effect on birth weight (β=38.9, p=0.000). Birth weight increases by 38.9 gram as gestational age increased by one week after adjusting sex of the infant.

The total, total indirect, direct and specific indirect effects of all variables in the structural model on birth outcomes are summarized in table 4.11. Since socioeconomic disadvantage, food insecurity and indoor air pollution are measured in different scales standardized coefficient are used. The total effect of socioeconomic disadvantage to birth weight was statistically significant with standardized coefficients (β=-0.668, p=0.000). The direct effect of socioeconomic disadvantage on birth weight had statistically non-significant (β=0.209, p=0.082) but total indirect effect was statistically significant (β=-0.877, p=0.000). These show that the direct effect of socioeconomic disadvantage to birth weight was fully mediated by other variables in the model. On the other hand socioeconomic disadvantage had a statistically significant direct effect on gestational age with non-significant total indirect effects (β=-0.093, p=0.093) and a significant total effect on gestational age (β=-0.550, p=0.000) confirming that it was not mediated by other variables in the model.
Out of the three specific indirect effects of socioeconomic disadvantage on gestational age none of the specific indirect effects had a significant effect on gestational age. For example the indirect effect of socioeconomic disadvantage through food insecurity on gestational age was not statistically significant (β=-0.050, p=0.347). The same is true for indoor air pollution and substance use. This shows that the effect of socioeconomic disadvantage on gestational age is not mediated by other variables in the model.

Three of the seven specific indirect effects had a statistical significant effect on birth weight. The effect of socioeconomic disadvantage through food insecurity to birth weight was statistically significant with standardized coefficient (β= -0.226, p=0.000). The indirect effect of SED through Indoor air pollution to birth weight was statistically significant with standardized coefficient (β= -0.488, p=0.000). The indirect effect of substance use that links socioeconomic disadvantage to birth weight was statistically significant with standardized coefficient (β= -0.058, p=0.004). However, the other indirect effects of SED through gestational age to birth weight were not statistically insignificant. For example the indirect effect of socioeconomic disadvantage through indoor air pollution and gestational age to birth weight was not statistically significant (β=-0.012, p=0.343). Of the indirect effects of SED to birth weight, indoor air pollution had a largest indirect impact on birth weight with standardized coefficient (β= -0.488, p=0.000); followed by food insecurity with standardized coefficient (β= -0.226, p=0.000).

Table 4.10 Total, total indirect, specific indirect and direct effect of exposure variable on birth outcomes

Path	Unstandardized estimates	Standard errors	Standardized estimates	P*-value
Effects from SED to GA				
Total effect	-2.309	0.477	-0.550	0.000
Total indirect effect	-0.392	0.499	-0.093	0.433
Direct effect	-1.917	0.781	-0.456	0.014
Effects from SED to BW				
Total effect	-574.5	1.028	-0.668	0.000
Total indirect effect	-754.2	1.493	-0.877	0.000
Direct effect	179.7	0.209	0.209	0.082
Specific indirect effects				
SED → SUB → GA	0.073	0.116	0.017	0.526
SED → Food → GA	-0.210	0.223	-0.050	0.347
SED → Indoor → GA	-0.256	0.298	-0.061	0.391
SED → GA → BW	-74.6	0.399	-0.087	0.061
SED → SUB → BW	-50.2	0.176	-0.058	0.004
SED → Food → BW	-194.5	0.494	-0.226	0.000
SED → Indoor → BW	-419.7	0.962	-0.488	0.000
SED → SUB → GA → BW	2.9	0.046	0.003	0.538
SED → Food → GA → BW	-8.2	0.081	-0.009	0.316
SED → Indoor → GA → BW	-9.9	0.105	-0.012	0.343

SED=socioeconomic disadvantage; Food=food insecurity; Indoor=indoor air pollution; SUB=substance use; GA= gestational age; BW= birth weight.
***Significant test for unstandardized coefficient**
**** Standard error for unstandardized coefficients**

4.8 Discussion of results

This section discusses the key findings and possible explanations associated with those findings. Maximum likelihood estimator is a robust estimator for most model parameter estimations. However, this is not always true because of the normality assumption. Hence, an alternative estimator was required. So comparison between ML and WLSMV estimators were made through their common fit indices for five models. ANOVA was applied for each fit indices whether or not the mean of fit indices for the five models between ML and WLSMV estimators are statistically different or not. The mean of all the fit indices for ML and WLSMV estimators are significantly different. For chi-square ratio and RMSEA with smaller mean of an estimator was best. However, CFI and TLI with large mean of an estimator were best. The findings of this study showed that WLSMV estimator had a smaller chi-square to the degree of freedom and RMSEA than ML estimator and had higher CFI and TLI values than ML estimators. This result happen might be because of the some of the ordinal dependent variables used in this study had less than five category and the outcome variables are not normally distributed. Over all the results of the entire fit indices showed that WLSMV estimator were superior to ML estimator for this study. So, all the model parameters of this study were estimated using WLSMV estimator.

The findings of this study shows that among the new born neonates in the sample, birth weights ranged from 1500 grams to 4300 grams (mean = 2962.47, SD = 477.36), and gestational ages ranged from 26 weeks to 46 weeks (mean= 38.8, SD = 2.332).

The result of this study shows that prevalence of low birth weight was 13.5% which is a little bit higher than previous study done in the same institution and lower than a study done in south west Ethiopia and EDHS. It was almost the same as Sub-Saharan African estimates but it is lower than a study done in Ghana and Guatemala (3-5, 12-14, 23) . This difference between countries was might be the study subject included in the study. For example a study done in Guatemala only includes rural subjects but this study includes both urban and rural respondents. This higher variations with in the country might be the case that recently ministry of health of Ethiopia had a campaign that “ANDIM ENAT BEWOLID MIKNYAT MEMOT YELEBATM” as well as the accessibility of ambulance brought those who delivered at home might be delivery to hospitals and probably, those mothers who were to give birth at home could be disadvantaged from different characteristics like knowledge, experience, etc. that could improve the chance of giving better birth outcome. In addition to that the methodology was also different. For instance EDHS uses a community based survey which does not measure the weight of the infant directly. They used a proxy variable to estimate the weight. So this might increase the prevalence of low birth weight in EDHS study.

The findings of study showed that the prevalence of preterm birth was 15.0% is similarly done on the same institution in Gondar referral hospital (14.3%) and study done Iran (15.5%) and it is lower than study done in Ghana (17%) but it was higher than the Global estimates 11.1%(2, 5, 11, 12). This difference was probably the measurement of gestational age. In this study Gestational age was estimated by the number of days between the first days of last menstrual period (LMP) and date of birth expressed in a completed weeks by interviewing the mother. This leads to a recall bias in remembering the last menstrual period.

The findings of this study showed that maternal socioeconomic disadvantage was not directly associated with birth weight. This shows that the distribution of birth weight across the socioeconomic hierarchy is the same or in other words the prevalence LBW is almost similar between low socioeconomic status and a mother at the highest socioeconomic status. This probably true when we see the measurement model of socioeconomic factor wealth index has the highest loading which means that the highest variation was explained by SED. Sometimes availability of wealth does not mean that utilization of all that wealth. This result was inconsistent with other studies (12, 15, 16). Another probable reason for our data not showing direct effect might be the magnitude of the effects of socioeconomic disadvantage was represented through mediated pathways such as food insecurity, indoor air pollution and substance use behaviors. In addition to the above reasons there might be a measurement difference between this study and the previous studies. In this study we used wealth index as proxy variable to measure socioeconomic disadvantage but the previous studies use income as a proxy variable to measure socioeconomic disadvantage(12, 15, 49).

The result of this study shows that maternal socioeconomic disadvantage was directly associated with decrease in gestational age. This result was consistent with other studies (12, 19, 21). However, there was no indirect effect between socioeconomic factors and gestational age. It is also showed that the direct effect of food insecurity, indoor air pollution and substance use behavior does not associated with gestational age. This result was not in line with some other studies (12). This probable case was the proxy variables used to measure socioeconomic factors as well as the different constructs used in this study. For example indoor air pollution construct measured by the number of fuel used for cooking during this pregnancy, the frequency of cooking per day and per week and staying in the cooking area but other studies they measured indoor air pollution only by one indicator variable number of fuel used (12). The other probable case might be the difference in the measurement of gestational age at delivery and the statistical methods used. In the current study, Gestational age was estimated by the number of days between the first days of the last menstrual period (LMP) and date of birth expressed in a completed weeks after LMP by interviewing the mother and structural equation modeling was used. However, other studies, the determination of gestational age was through ultrasound dating which is important to find the exact measure of gestational age(30).

The result of this study shows that of the seven indirect effects from socioeconomic disadvantage to birth weight only three are significant. There is significant association between socioeconomic disadvantage and birth weight operated through indoor air pollution. In this study when we looking the standardized coefficients indoor air pollution was the most important indirect effect of between SED and birth weight, the highest impact in decreasing in birth weight of the infant(β=-0.488) followed by food insecurity(β=-0.226). This effect was happened when a pregnant mother exposed ambient air pollution and also from carbon monoxide when they use biomass cooking fuel that affects indirectly the growth of the infant inside the womb and as a consequence it decrease the birth weight of the infants. This result was consistent with other studies done in Ghana, Guatemala and Zimbabwe (12, 13, 36).

One of the finding of this study mediated by food insecurity was that socioeconomic disadvantage and birth weight. Socioeconomic disadvantage and food insecurity are positively and significantly associated and also food insecurity is negatively and significantly associated with birth weight after adjusting the sex of the infant. This result was in line with other studies (12, 29, 33). They showed that food insecurity was negatively associated with birth weight. This factor is prevalent in Ethiopia and is risky for mothers who are food insecure before and after pregnancy. One reason is that food insecure mother during pregnancy was related to insufficient iron stores and with diet inadequate in Folate. This poor iron and folic acid status have been linked to reduced birth weight(33). This exposure variable is the second factor next to indoor air pollution that significantly and negatively affects birth weight.

The result of this study revealed that socioeconomic disadvantage and birth weight was mediated by substance use behavior of the mother. Socioeconomic disadvantage and substance use was positive and significantly associated in turn substance use is negatively and significantly associated with birth weight when adjusted for sex of the infant. This result was consistent with other studies (16, 30, 38, 39).

Findings from this study also shows that gestational age was positively associated with birth weight but socioeconomic disadvantage and birth weight did not mediated by gestational age or a combination of gestational age and other exposure variables such as food insecurity, indoor air pollution and substance use after adjusting by sex of the infant. This result was consistent with other study(5).

Overall, socioeconomic disadvantage did not directly affect birth weight. Effects of socioeconomic disadvantage to birth weight were indirectly and significantly affected by indoor air pollution, food insecurity and substance use behavior of the mother during pregnancy but socioeconomic disadvantage to birth weight were not indirectly affected by gestational age and the combination of gestational age and other exposure variables. The largest indirect effect was expressed through indoor air pollution followed by food insecurity. Socioeconomic disadvantage was directly affect gestational age. However, socioeconomic disadvantage to gestational age were not indirectly affected by indoor air pollution, food insecurity and substance use behavior of the mother during pregnancy.

5 Conclusion and Recommendations

5.1 Conclusion

In this study the pathway between socioeconomic disadvantage and birth outcomes of new born neonates of Gondar teaching referral and Bahir Dar Felege Hiwot referral hospitals in May 1, 2015 to May 30, 2015 has been studied. Based on common fit indices of the ML and WLSMV estimators using cut-off point of the fit indices and ANOVA, WLSMV estimator was superior to ML estimator for this study. Among the new born neonates in the sample, birth weights ranged from 1500 grams to 4300 grams (mean= 2962.47, SD = 477.36), and gestational ages ranged from 26 weeks to 46 weeks (mean = 38.8, SD = 2.332). The prevalence of low birth weight is 13.5% and the prevalence of preterm birth is 15.0%. According to structural equation modeling socioeconomic disadvantage indirectly affects birth weight and directly affects gestational age. In addition to this, birth weight is negatively and significantly influenced by indoor air pollution; food insecurity and substance use behavior of the mother and positively associated with gestational age. However, gestational age was not affected by indoor air pollution, food security and substance use behavior of the mother. The pathway that links socioeconomic disadvantage to birth weight is indoor air pollution, food insecurity and substance use behavior. However, there is no pathway links socioeconomic disadvantage to gestational age.

5.2 Recommendations

Based on our research findings, we would like to forward the following;

- Efforts should be focused on socioeconomic improvement of the mother.
- Intervention and preventive strategies should be focus on food security situation of a mother before and during pregnancy.
- Special attention was given to a mother during pregnancy of her cooking frequency, staying in a cooking area and the number of fuel used for cooking.
- Create awareness not to use alcohol and illicit drug during pregnancy through media or any other means.

Policy implication

Based on our research findings, we would like to forward the following police implications

- The government of Ethiopia is continuing to economic growth in sustainable manner to improve the socioeconomic condition of the household in turn improve the mother.
- Ministry of agriculture work hard to avoid food security situation of the mother before and during pregnancy.
- The problem of Indoor air pollution condition of a mother is avoided according to
  In the short run; ministry of health work hard on this area. The health extension workers educate the society on how to use cooking fuel. They educate the pregnant mother their

cooking session should be with in a ventilated area as well as in an open air. And also during pregnancy the number of cooking session decreased.

In the long run:-The ministry of energy is work hard to address clean energy use for cooking food for each and every households in rural and urban areas.

- The problem of Substance use behavior of a pregnant mother addressed through ministry of health via health extension workers. The health extension workers work hard to teach the pregnant women not to use alcohol and illicit during.

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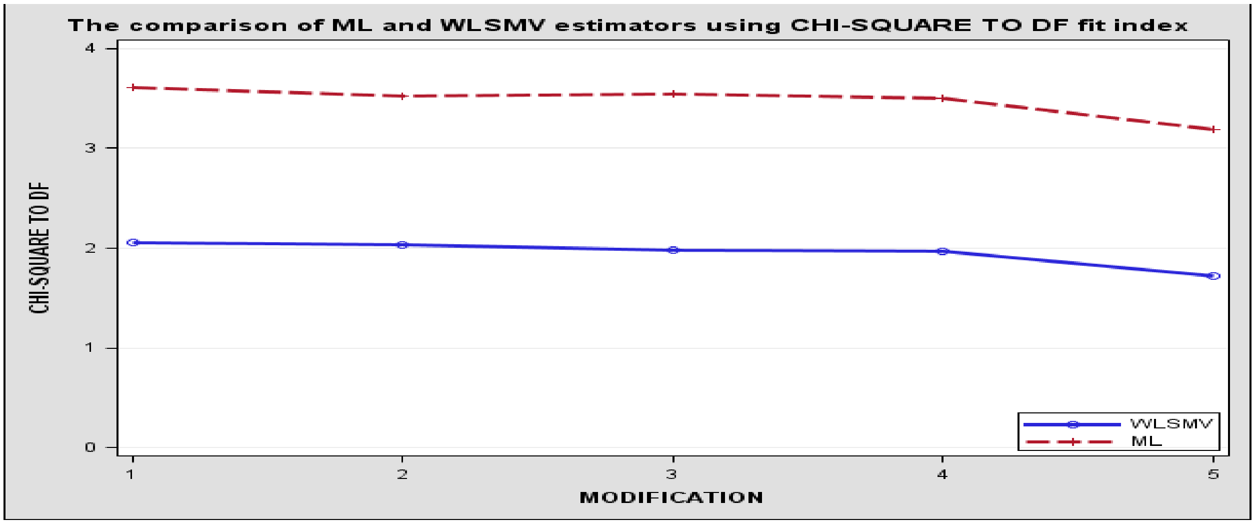
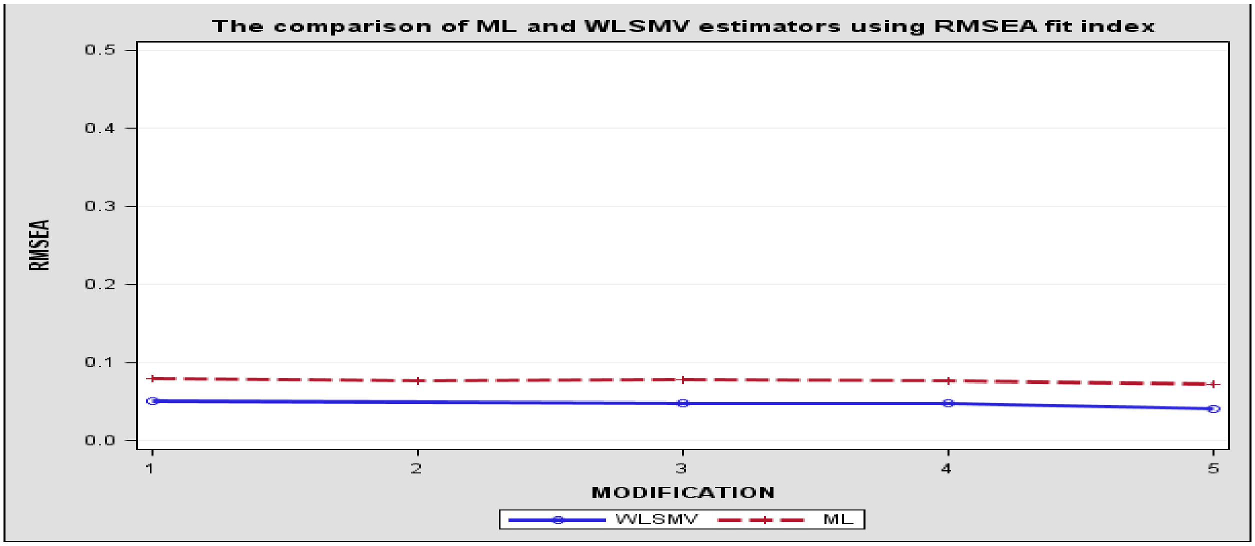
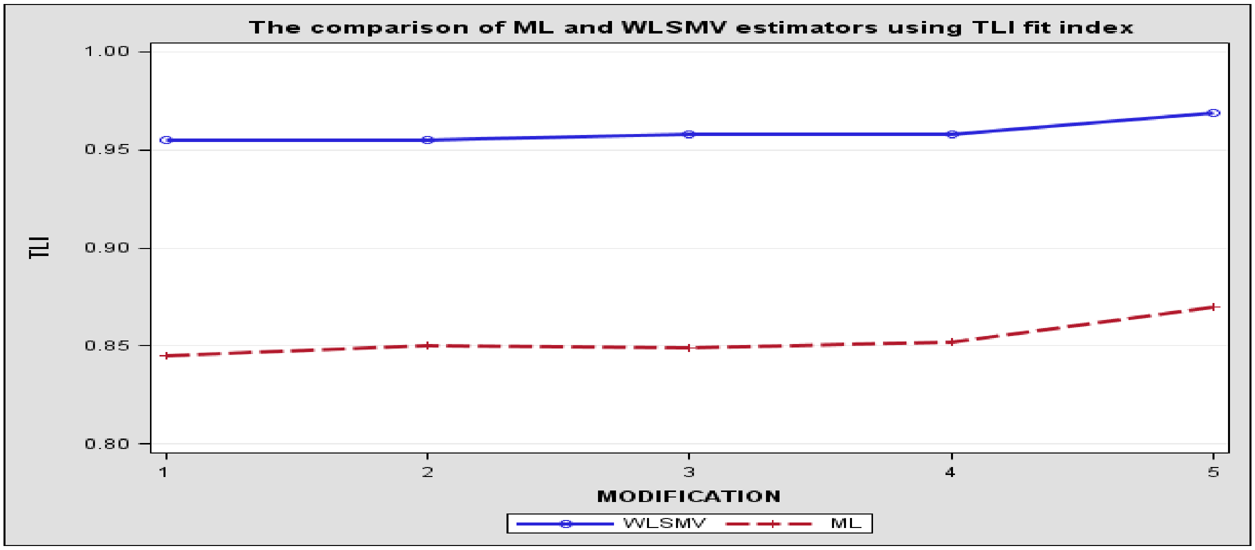
7 Appendix

7.1 Annex 1; Fit indices figures for ML and WLSMV estimators.







7.2 Annex 2; English questionnaire

English questionnaire

Gondar University

Faculty of natural and computational science

Statistics department

Face to face interview questionnaire for the effect of substance use, indoor air pollution, physical activity and food insecurity mediate socioeconomic position and adverse birth outcomes using structural equation modeling.

GREETING!

"Good Morning/Afternoon my name is ___________________________________ this study is conducted by Mr. Yeshambel workie, final year post graduate student of University of Gondar statistics department. The purpose of this study is to identify the distribution and prevalence of birth weight and gestational age and factors affecting it.

As the study is directly related to your current pregnancy and your infant health status. You are one of the respondents who are selected to involve in this study, therefore kindly requested to participate. I would like to assure you that all of your responses to the question will be kept confidentially.

Your name will not be written and everything you tell me will be kept strictly confidential. Your participation will be voluntarily. We would like to inform you that the response that you provided the questions is very important, not only for the successful accomplishment of the study but also for producing relevant information which will be helpful in improving the health status of an infant in Gondar teaching referral hospital and Bahirdar felege hiwot referral hospital.

Questionnaire identification number__________________

Name of data collector ____

Date of interview ______________________________________

Checked by supervisor name ____________________ sign.______________ date___________

Section I: Socio-demographic characteristics

101. What is the age of the respondent during delivery? ⟶ ☐

102. Marital status of the mother?

1. Single 2. Married 3. Divorced /separated

103. The religion of the mother? 1. Christian 2. Muslim 3. Protestant 4. Catholic 5. Others.

104. The usual residence of the mother 1. Urban 2. Rural

105.Have you ever attended school? 1 Yes 2 No ⟶ skip to section II

106.What is the highest grade/number of years you completed at that level? ⟶ ☐

Section II: Economic characteristics

201 .Does your households have?

Number	Materials found in the house hold	Yes	No
201.1	Electricity		
201.2	A refrigerator		
201.3	A radio		
201.4	A television		
201.5	A mobile telephone		
201.6	A non-mobile telephone		
201.7	A clock		
201.8	A chair/ sofa		
201.9	A table		
201.10	A bed with cotton/sponge/spring mattress?		
201.11	An electric mitad		
201.12	A kerosene lamp/ pressure lamp		

202.Main material of the floor a house is made.

1. Earth/sand 2. Dung 3. Rudimentary floor Wood planks
4. Palm/Bamboo 5. Polished wood 6. Vinyl or Asphalt strips 7.Ceramic tiles
8. Cement 9. Carpet 10. Other(specify)------------------

203. Main material of the roof which the house is made.___________________

1. No roof 2. Thatch/leaf/mud 3. Plastic sheets 4.Reed/bamboo
5. Wood plank 6. Cardboard 7. Finished roofing corrugated iron/metal

8. Wood 9. Asbestos/cement fiber 10. Cement/concrete 11.Roofing shingles

204. Main material of the interior/exterior walls. ____________________

1. No well 2. Cane/bamboo/trunks/reed 3. Dirt 4. Bamboo/wood with mud
5. Stone with mud 6. uncovered adobe 7. Plywood 8. Cardboard
9. Reused wood 10. Cements 11. Stone with cement
12. Bricks 13. Cement blocks 14. Covered adobe 15. Wood planks/ shingles

205. How many numbers of people are living in this household? __________

206. Does any member of this household have assets?

No	Material name	Yes	No
206.1	Bicycle		
206.2	Motorcycle		
206.3	An animal drawn cart		
206.4	Car or truck		

207.Does any member of this household have any agricultural land? 1. Yes 2. No→skip 209

208.How many of agricultural land do members of this household have?_______ (in Local Units)

209.Does this household have own livestock, herds, other farm animals or poultry?

1. Yes 2. No⟶ skip to Q 211

210.How many of the following animals does this household have?

No	Animal name	Amount
210.1	Milk Cows	
210.2	Heifers	
210.3	Oxen	
210.4	Bulls	
210.5	Donkeys	
210.6	Mules	
210.7	Horse	
210.8	Camels	
210.9	Goats	
210.10	Sheep	
210.11	Chickens	
210.12	Beehives	

211.Does any member of this household have a bank or microfinance saving account?

1. Yes 0. No

212. What is the main source of drinking water for members of your household?

1. River/lake/pond 2. Spring water 3. Tape public 4. Tape private
5. Dug well public 6. Dug well private 7. Bottled water

213. What kind of toilet facility do members of your household usually use?

1. Flash to piped water 2. Pit latrine (public) 3. Pit latrine (private) 4. Bush/field

Section III: Birth outcomes

301 What was the baby's weight in grams? →
302 What was the baby's gestational age in weeks? →
303 Mode of delivery? 1. Normal 2. Cesserian
304 What is the sex of the baby's? 1. Male 2.Female
305 Did you see anyone for antenatal care for this pregnancy? 1 Yes 2 No → skip to Q.307
306 How many times did you recieve antenatal care during this pregnancy? →

307 Does the baby have any birth deficit during delivery? 1. Yes 2. No skip to section IV
308 What type of birth deficit are appeared------------------------?

Section IV: Substance use

401 Have you ever chewed chat during current pregnancy?
1. Yes 2. No → skip to Q 403
402 .During this pregnancy, on average how many days did you chew chat per month? →
403. During this pregnancy, have you taken "hashishi"? 1. Yes 2. No → skip to Q 405
404 .During this pregnancy on average how many days did you take hashishi per month?

405. During this pregnancy have you taken a drunk that contains alcohol such as (Tella|Teji|Areke|Beer|wine.etc.) 1 Yes 2. No → skip to Q407
406. During this pregnacy , on average how many days did you take a drink that contains alcohol per Month? →

407. During this pregnancy did you take any type of drug duet to illness?
1. Yes 2. No → skip to section V
408 Who ordered to take this drug?
1. My self 2. Nurse/health ex tession worker/doctor → skip section V
409 what type of drug you took? ------------------ ----------------------

Section V: Indoor air pollution

501.What types of fuel does your household used for cooking? (more than one answer)
1 Natural gas 2. Biogas 3 kerosene 4. Charcoal 5. Wood 6. Shrubs/Grass
7 Agricultural crop 8 Animal dung 9. Other(specify)
502.What type of fuel does your household mainly use for cooking?
1. Electricity 2. Natural gas 3. Biogas 4. Kerosene 5. Charcoal 6. Wood
7 . Shrubs/Grass 8. Agricultural crop 9. Animal dung 10 .Other(specify)
503 During this pregnancy, how many times a day on average you cook food using biomass fuel? →

504. During the current pregnancy how many days in a week on average you cook food using a biomass fuel only? →
505.How do you rate staying in each cooking session when using a biomass fuel?
1. staying in a cooking area for up to half the duration of each cooking session
2. staying in a cooking area through out the whole duration of each cooking
506 How do rate your cooking area ventilation?
1. very poor ventilation 2. poor ventilation 3. good ventilation 4. Very good ventilation

sectionVI: Food insecurity

601. During this pregnancy, you were worried you would run out of food because of lack

money or other resourses? 1. Yes 0. No

602. During this pregnancy you were unable to eat healthy and nutritious food because of lack of Money or other resourses 1 Yes 0. No

603. During this pregnancy you ate only a few kinds of food because of a lack of money Or other resourses 1 Yes 0 No

604. During this pregnancy you had to skip a meal because there was not enough money or other Resources to get food? 1 Yes 0 No

605. During this pregnancy you ate less than you thought you should because of lack money or Other resources? 1 Yes 0 No

606. During this pregnancy your household run out of food because of lack of money or Other resources 1 Yes 0 No

607. During current pregnancy , you were hungery but did not eat because of there was not enough money Or other resourses? 1 Yes 0 No

608. During current pregnancy you went without eating for whole day because of lack of money or other Resources? 1 Yes 0 No

7.3 Annex 3; Amharic questionnaire

የአማረኛ መጠይቅ

ጎንደር ዩኒቨርሲቲ
የተፈጥሮና ቀመር ሳይንስ ኮሌጅ

የስታቲሰቲክስ ት/ክፍል

በአማራ ክልል በባህርዳር እና በጎንደር አጠቃላይ ሆስፒታል የሚዎለዱ ህፃናት ክብደታቸወን እና ያለጊዜቸው የሚወለዱበትን የሚወስኑ ነገሮች እንዲሁም ስርጭቱን አስመልክቶ ምርምርና ጥናት ለማድረግ የሚያግዝ በአማረኛ የተዘጋጀ መጠይቅ ነው፡፡

ጤና ይስጥልኝ!

ስሜ ______________________________ ይበላል፡፡የሀ ጥናት በጎንደር ዩኒቨርስቲ በሰታቲሰቲክስ ት/ክፍል የድህረ ምረቃ የመጨረሻ ዓመት ተማሪ በሆኑት በአቶ የሻመበል ወርቄ የሚካሄድ ሲሆን የጥናቱ አላማም የሚዎለዱ ህፃናት ክብደታቸወን እና ያለጊዜቸው የሚወለዱበትን የሚወስኑ ነገሮቸን እንዲሁም ስርጭቱን አስመልከቶ ምርምርና ጥናት ማድረግ እና በምን ደረጃ ላይ እንደሚገኙ ለማዎቅ ነው፡፡

ጥናቱ በቀጥታ የሚመለከተዉ እናቶች በእርግዝና ወቅት ሰለነበራቸው ጊዜ እና ስለወለዱት ህፃን ጤንነት ስለሆነ በአጋጣሚ ለጥናቱ ከተመረጡ ተሳታፊዎች መካከል አንዷ ሲሆኑ በጥናቱ እንዲሳተፉ በአክበሮት ጋብዘንዎታለ፡፡ የሚሰጡንን መረጃ መሉ በሙሉ በሚስጥር እንደምንይዝ ላረጋግጥለዎ እፈልጋለሁ፡፡

ስመዎን አንፅፍም የሚነግሩንም ማንኛውንም ነገር ሚስጥራዊነቱ የተጠበቀ እነደሚሆን ደግሜ አረጋግጥልዎታለሁ፡፡ ተሳትፎዎ በፍቃደኝነት ላይ የተመሰረተ ነው፡፡ መመለስ የማይፈልጉትን ማንኛውንም ጥያቄ እንዲመልሱ አይገደዱም፡፡ ሌላው ልገልፅለዎት የምፈለገው ጉዳይ እርሰዎ የሚሰጡን መረጃ ለጥናቱ መሳካት ብቻ ሳይሆን አነስተኛ ክበደት እና ያለጊዜቸው የሚዎለዱትን ህፃናት ለመቀነስ የሚያስችል ፖሊሲ ለመቅረጽ ያሰችላል፡፡ ጥያቄው ከ 20 አስከ 25 ደቂቃ ይወሰድበናል፡፡

አጠቃላይ መረጃ

የመረጃ ሰጭዉ መለያ ቁጥር______________

መጠይቁ የተደረገበት ቀን__________________________

የመረጃ ሰብሳቢዉ ሙሉ ስም__________________________

መጠይቁን ያየዉና ያረጋገጠዉ ተቆጣጣሪ ስም______________________ፊርማ______________ቀን_______________

ክፍል 1፡- የስነ ህዝብ እና ማህበራዊ ጥያቄዎች				
ተ.ቁ	ጥያቄ	መልስ	ኮድ	እለፍ
101	በሚዎልዱበት ጊዜ ዕድሜዎ ስንት ነበር?	_______________		
102	የጋብቻ ሁኔታ እንዴት ነው	1. ያላገባ 2. ያገባ 3 የተፋታ 4. የሞተበት 5. የተለያየ		
103	ሀይማኖትዎ ምንድን ነዉ;	1. ኦርቶዶክስ 2. ሙስሊም 3.ፕሮቴስታንት 4. ካቶሊክ 5. ሌላ (ይገለጽ)_________		
104	የመኖሪያ አድራሻ	1. ገጠር 2. ከተማ		
105	መደበኛ/መደበኛ ያልሆነ ትምህርት ተከታትለው ያውቃሉ?	1. አዎ 2. የለም →		ክፍል 2
106	ያጠናቀቁት ከፍተኛ የትምህርት ደረጃዎ ስንት ነዉ;? **(ለጥያቄ 105 መልሰዎ አዎ ከሆነ)**	1. ማንበብና መጻፍ የማይችል 2. መደበኛ ያልሆነ ትምህርት 3. አንድኛ ደረጃ ትምህርት 4. ሁለተኛ ደረጃ ትምህርት 5. ሰርተፍኬት 6. ዲፕሎማ 7. ባችለር ዲግሪ እና ከዛ በላይ		
107	ያጠናቀቁት ከፍተኛ ክፍል በሙሉ ዓመት ስንት ነው?	በሙሉ ዓመት-----------------------------		

ክፍል 2፡- ኢኮኖሚያዊ ሁኔታ				
ተ.ቁ	ጥያቄ	መልስ	ኮድ	እለፍ
201	የሚከተሉት እቃዎች አሉዎተ ውይ?			
	በቤተሰብ ደረጃ የእቃዎቹ ዝርዝር			
	201.1 የኢለክትሪክ መብራት	1 አዎ 2. የለም		
	201.2 ፍሪጂ (ማቀዘቀዣ)	1 አዎ 2. የለም		
	201.3 ሬዲዮ	1 አዎ 2. የለም		
	201.4 ቴለቭዥን	1 አዎ 2.የለም		
	201.5 የሞባይል ስልክ	1 አዎ 2. የለም		
	201.6 የቤተ(የመስመር) ስልክ	1 አዎ 2. የለም		

	201.7 የእጅ ሰዓት	1 አዎ 2. የለም		
	201.8 ወንበር(ሶፋ)	1 አዎ 2. የለም		
	201.9 ጠረጴዛ	1 አዎ 2. የለም		
	201.10 አልጋ ከጥጥ/ስፖንጂ/ሰፒሪንግ ፍራሽ ጋር	1 አዎ 2. የለም		
	201.11 የኤሌክትሪክ ምጣድ	1 አዎ 2. የለም		
	201.12 የላምባ/በግፊት የሚሰራ ፋኖስ	1 አዎ 2. የለም		
202	የቤቱ ወለል የተሰራው ከምን ነው?	1. ከአፈር/አሸዋ 2. በበት የተለቀለቀ 3. ከእንጨት 4. ሸበቆ/ከቅርቀሃ 5. ከጣውላ 6. አስፋለተ 7. ሴራሚክ 8. ሲሚንቶ 9. ስጋጃ/ምንጣፍ 10. ሌላ(ይገለፅ)…………………………		
203	የቤቱ ጣሪያው ክዳን የተሰራው ከምን ነው?	1. ክዳን የለውም 2. የሳር ክዳን 3. ከፕላስቲክ 4. ከሸበቆ/ከቅርቀሃ 5. ከጣውላ 6. ከካርቶን 7. ከቆርቆሮ 8. ከእንጨት 9. ሲሚቶ ለባስ 10. ኮንክሪት 11. ከጠጠር		
204	የቤቱ ግድግዳ የተሰራው ከምን ነው?	1. ግድግዳ የለውም 2. ከቅርከሃ 3. ከውደቅዳቂ እንጨት 4. ከእንጨት ከቅርቀሃ እና ከጭቃ 5.. ከድንጋይ እና ከጭቃ 6. ያልተሸፈኘ ጡብ 7. ከጣውላ 8. ከካርቶን 9. ጥከም ላይ ከዋለ እንጨት 10. ከሲሚቶ 11. ከድንጋይና ከሲሚቶ 12. ከጡብ 13 ከቡለኬት 14 ከእንጨት		
205	የቤተሰቡ አባላት ብዛት ስንት ነው(አብረው እየተመገቡ ባአንድ ቤት ወይም በተቀራረበ ቤት አብረው የሚኖሩ)?	በቁጥር…………………………………………………………		
206	ከቤተሰቡ አባላት ውስጥ የሚከተሉት ንብረቶች ያለው አለ ወይ?			
	206.1 ሳይክል	1. አለ 2. የለም		
	206.2 ሞተር ሳይክል	1. አለ 2. የለም		
	206.3 በእንስሳት የሚጎተት ጋሪ	1. አለ 2. የለም		
	206.4 መኪና	1. አለ 2. የለም		
207	ከቤተሰቡ አባላት ውስጥ ለግብርና ስራ የሚውል የእርሻ መሬት ያለው አለ ወይ?	1. አዎ 2. የለም →		ጥ 209
208	ምን ያህል ሄክታር ይሆናል?	በሄክታር………………………………		
209	ይህ ቤተሰብ የራሱ የሆኑ የቀንድ ከብቶች፣የጋማ ከብቶ እንዲሁም ደሮዎች ፣ንብ የያዙ ቀፎዎች አሉት ውይ?	1. አለ 2. የለም →		ጥ.211

210	የእንስሳቱ ስም	ብዛተ		
	210.1 የወተት ላሞች	ቁጥር,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	210.2 ጊደር	ቁጥር,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	210.3 በሬ	ቁጥር,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	210.4 ኮርማ	ቁጥር,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	210.5 አህያ	ቁጥር,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	210.6 በቅሎ	ቁጥር,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	210.7 ፈረስ	ቁጥር,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	210.8 ግመል	ቁጥር,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	210.9 ፍየል	ቁጥር,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	210.10 በግ	ቁጥር,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	210.11 ደሮ	ቁጥር,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	210.12 ንብ ያላቸው ቀፎዎች	ቁጥር,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
211	ከቤተሰቡ ውስጥ የባንክ ደብተር ያለው አለ ወይ?	1. አዎ 2. የለም		
212	ቤተሰቡ በዋነኛነት የመጠጥ ውሃ ምንጩ ምንድን ነው?	1. ከወንዝ /ከሀይቅ/ከኩሬ 2. ከምንጭ 3. ከቦኖ(የጋራ) 4. ከቦኖ(የግል) 5 ከጉድጓድ(የጋራ) 6. ከጉድጓድ(የግል) 7. የታሸገ ውሃ		
213	በአብዛኛው ቤተሰቡ በምን አይነት ሽንት ቤት ነው የሚጠቀመው?	1. የውሃ ማፈሻሻ ያለው ሽንት ቤት 2. የጉድጓድ(የጋራ) ሽንት ቤት 3. የጉድጓድ (የግል) ሽንት ቤት 4 መሜዳ/በጫካ		

ክፍል 3፡-የተወለደውን ህፃን በተመለከተ				
ተ.ቁ	ጥያቄ	መልስ	ኮድ	እለፍ
301	የህፃኑ ክብደት ወዲያው እንደተወለደ ስንት ነው? (ከካርድ የሚሞላ)	--------------------ግራም		
302	የህፃኑ የእርግዝና ጊዜ ስንት ሳምንት ነው? (ከካርድ የሚሞላ)	------------------ሳምንት		
303	የአወላለድ ሁኔታ? (ከካርድ የሚሞላ)	1. በትክክለኛው 2. ቀዶ ጥገና		
304	የህፃኑ ፆታ	1. ወንድ 2. ሴት		
305	የእርግዝና ክትትል አድርገው ነበር ወይ?	1. አዎ 2. የለም →		ጥያቅ307
306	ለምን ያህል ጊዜ የእርግዝና ክትትል አደረጉ?	በቁጥር------------------		

307	ልጁ ወዲያው እንደተዎለደ የጤና ችግር ነብረበት ወይ? (ከካርድ የሚሞላ)	1. አዎ 2. የለም →		ክፍል 4
308	ምን ዓይነት ችግር ነው ያለበት? (ከካርድ የሚሞላ)	1. --------------- 2. ----------------		

ክፍል 4፡-በርግዝና ወቅት የሚጠቀሞቸው ነገሮች(የጫት፣አሸሽ እና የአልኮል አጠቃቀምን በተመለከተ)?				
ተ.ቁ	ጥያቄ	መልስ	ኮድ	እለፍ
401	በአሁኑ እርግዝና ወቅት ጫት ተጠቅመው ነበር ወይ?	1. አዎ 2. የለም →		ጥ 403
402	በአማካኝ በወር ለምን ያህል ቀን ጫት ይጠቀማሉ?	በቁጥር----------------------		
403	በአሁኑ እርግዝና ወቅት አሸሸ ተጠቅመው ነበር ወይ?	1. አዎ 2. የለም →		ጥ 405
404	በአማካኝ በወር ለምን ያህል ቀን አሸሸ ተጠቀሙ?	በቁጥር----------------		
405	በአሁኑ እርግዝና ወቅት ጠላ፣ጠጂ፣አረቂ፣ ቢራ፣ወይን ወይም አልኮል ነክ ነገሮችን ተጠቅመው ነበር ወይ?	1. አዎ 2. የለም →		ጥ 407
406	በአማካኝ በወር ለምን ያህል ቀን ጠላ፣ጠጂ፣አረቂ፣ ቢራ፣ወይን ወይም አልኮል ነክ ነገሮችን ተጠቀሙ?	በቁጥር------------------		
407	በአሁኑ እርግዝና ወቅት በህመም ምክንያት መድሀኒት ተጠቅመው ነበር ወይ?	1. አዎ 2. የለም →		ክፍል 5
408	የተጠቀሙትን መድሀኒት ማን አዘዘለዎ?	1. በራሴ ገዝቸ ነው 2. በሀኪም ትዛዝ ነው →		ክፍል 5
409	በራሰዎ ገዝተው ከሆነ የመድሀኒቱ ስም ምን **ይባላል?(ወይም ለምን ህመም እንደዎሰዱ ተጥቆ የመድሀኒቱ ዓይነት ይሞላ)**	---		

ክፍል 5 የቤት ውስጥ የአየር ብክለት ሁኔታን በተመለከተ				
ተ.ቁ	ጥያቄ	መልስ	ኮድ	እለፍ
501	ምግብ ለማብሰል የሚጠቀሙበት የነዳጂ/የማገዶ ዓይነት ምንድን ነው? (ከአንድ መልስ በላይ ይቻላል)	1. የተፈጥሮ ጋዝ 2. ባዮ ጋዝ 3. ነጭ ጋዝ 4. ከሰል 5. እንጨት 6 ቂጥቾጦ/ሳር 7. የሰብል ቀሪት 8. ኩበት 9. ሌላ(ይገለፅ፲-------		
502	ምግብ ለማብሰል በዋናነት የሚጠቀሙበት የነዳጂ/የማገዶ ዓይነት ምንድን ነው?	1 ኤለክትሪክ 2. የተፈጥሮ ጋዝ 3. ባዮ ጋዝ 4 ነጭ ጋዝ 5. ከሰል 6. እንጨት 7 ቂጥቾጦ/ሳር 8. የሰብል ቀሪት 9 ኩበት 10 ሌላ(ይገለፅ፲---------		

503	ኤለከሪከ ሳየጨመረ በአማካኝ በቀን ስንት ጊዜ ምግብ ያበስላሉ?	በቁጥር---------------		
504	ኤለከሪከ ሳየጨመረ በአማካኝ በሳምንት ለስንት ቀን ምግብ ያበስላሉ?	በቁጥር---------------------		
505	ኤለከሪከ ሳየጨመረ በእያንዳንዱ የምግብ ማብሰያ ጊዜዎ የቆይታውን ጊዜ እንዴት ይገልጹታል?	1. እስከ ግማሽ የማብሰያ ጊዜው እቆያለሁ 2. ሙሉ በሙሉ የምግቡ የሙብሰያ ጊዜ እስኪአልቅ እቆያለሁ.		
506	የምግብ ማብሰያ ቦታው የንፋስ መግቢያ መስኮት አለው ወይ?	1. አለው 2. የለውም		
507	በአጠቃላይ የምግብ ማብሰያ ቦታው ማናፈሻ እንዴት ይገልፁታል?	1. በጣም አነስተኛ ማናፈሻ ነው ያለው 2. አነስተኛ ማናፈሻ ነው ያለው 3. ጥሩ ማናፈሻ ነው ያለው 4. በጣም ጥሩ ማናፈሻ ነው ያለው		
ክፍል 6 የምግብ ዋስትናን ሁኔታን በተመለከተ				
ተ.ቁ	ጥያቄ	መልስ	ኮድ	እለፍ
601	በአሁኑ እርግዝና ወቅት በገንዘብ ወይም በገንዘብ ምንጭ እጥረት ምክንያት ለመጪው ግዜያት ምግብ ላይኖረኝ ይችላል ብለው እጅግ የተጨነቁበት ወቅት ነበር?”	1.አዎ 0. የለም		
602	በአሁኑ እርግዝና ወቅት በገንዘብ ወይም በገንዘብ ምንጭ እጥረት ምክንያት ጤነኛ እና በንጥረ ነገር የበለጸገ ወይንም የተመጣጠነ ምግብ ለመመገብ አለመቻል የደረሱበት ወቅት ነበር?	1. አዎ 0.የለም		
603	በአሁኑ እርግዝና ወቅት በገንዘብ ወይም በገንዘብ ምንጭ እጥረት ምክንያት የጥቂት ዓይነት ምግቦች ብቻ ወይም ተመሳሳይነት ያላቸውን ውስን የሆኑ ምግቦችን ብቻ የተመገቡበት ወቅት ነበር?	1.አዎ 0.የለም		
604	በአሁኑ እርግዝና ወቅት በቀን ውስጥ በተለመደው ሰዓት መመገብ ከሚገባዎት ምግቦች እንደ ቁርስ፣ ምሳ፣ ራት ዓይነት ውስጥ በገንዘብ ወይም በገንዘብ ምንጭ እጥረት ምክንያት አንዱን ወይንም ሌላውን ያሳለፉበት ወይንም እንዲያሳልፉ የተገደዱበት ጊዜ ነበር?	1.አዎ 0. የለም		
605	በአሁኑ እርግዝና ወቅት በቀን ውስጥ በተለመደው ሰዓት መመገብ በሚኖርበት ሰዓት እየተመገቡ ነገር ግን በገንዘብ ወይም በገንዘብ ምንጭ እጥረት ምክንያት ሙብላት አለብኝ ብለው ካሰቡት ወይንም እንደ ራሴ ሙብላት ያለብኝ መጠን ይህ ነው ብለው ከሚያምኑት በታች የበሉበት ጊዜ ነበር?	1.አዎ 0 የለም		
606	በአሁኑ እርግዝና ወቅት በገንዘብ ወይም በገንዘብ ምንጭ እጥረት ምክንያት እርስዎ በቤትዎ ምግብ አልቆቦት ወይንም ምንም ዓይነት ምግብ በቤትዎ ውስጥ ሳይኖር ቀርቶ ያውቃል?	1.አዎ 0. የለም		
607	በአሁኑ እርግዝና ወቅት በገንዘብ ወይም በገንዘብ ምንጭ እጥረት ምክንያት ተርበው ያልበሉበት ጊዜ ነበር?	1.አዎ 0. የለም		
608	በአሁኑ እርግዝና ወቅት በገንዘብ ወይም በገንዘብ ምንጭ እጥረት ምክንያት ቀኑን ሙሉ ሳይበሉ የዋሉበት ጊዜ ነበር?	1.አዎ 0. የለም		